4
RESULTS

4.0 RESULTS

4.1 The growth performance of purebred and crossbred goats at Kluang and Serdang.

4.1.1 Birth weight of goats at Kluang

The mean birth weight and subsequent monthly body weights to one year old for the purebred and crossbreds at Kluang are presented in Table 4.01 and graphically in Figure 4.01. Among the four breed groups the Anglo Nubian purebred (AA) had a birth weight of 2.17±0.45 kg which was lower than that of the Jamnapari purebred (JJ) and Jamnapari x Katjang crossbred (JK) although the subsequent body weights of Anglo Nubian purebred (AA) was higher than that of the other three breed groups. This result contradicts earlier results of Devendra (1962) who suggested that the birth weight of Anglo Nubians in Malaysia could be as high as 2.50 kg in males and 3.86 kg in females. This difference is attributed to the fact that Devendra's group of animals was from a selected group for a nutritional trial, whereas the animals in this study were unselected. Gill and Dev (1962), Castillo et al., 1976) and Bellaver et al., (1980) in other countries also recorded higher birth weights of Anglo Nubian purebreds (AA) compared to the results of the present study. The level of concentrates fed to the pregnant females in their study was much higher than in this study.

The birth weights in the four breed groups ranged from 2.0-3.0 kg in Anglo Nubian purebred, 1.4-4.1 kg in Jamnapari purebred, 1.0-5.0 kg in Jamnapari x Katjang and

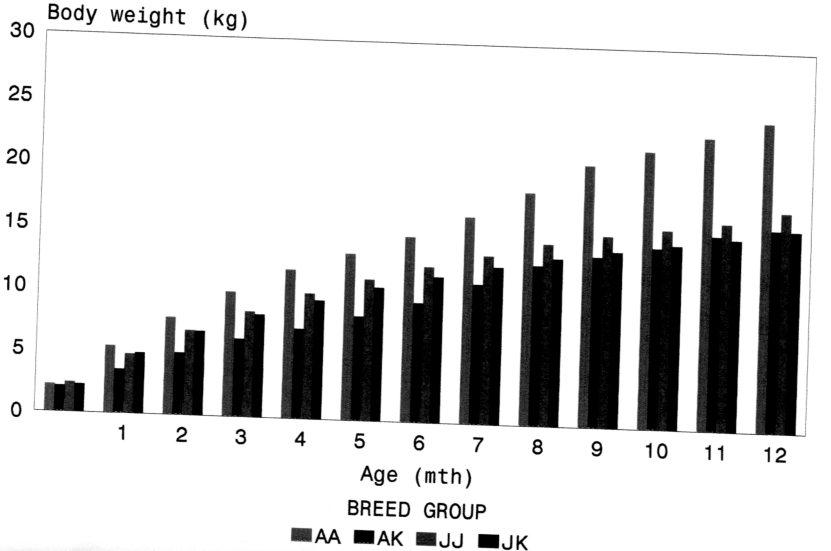
Table 4.01: Least square means (±S.E) for birth, weaning and year-old body weights in purebred and crossbred goats at Kluang.

Breed	N	Birth wt	Weaning wt	Year-old wt
AA	151	$2.17\pm0.45_{b}$	$9.91\pm4.35_{a}$	$24.51\pm8.74_{a}$
JJ	748	$2.36\pm0.54_{a}$	$8.38\pm2.27_{ab}$	$17.48\pm3.86_{b}$
JK	3539	$2.21\pm0.47_{b}$	$8.17\pm2.16_{ab}$	$16.00\pm3.55_{b}$
AK	516	$2.07\pm0.69_{c}$	$6.18\pm1.82_{b}$	$16.08\pm5.18_{b}$

Means with same subscripts in column are statistically not different (P>0.05)

Breeds AA = Anglo Nubian purebred
JJ = Jamnapari purebred
JK = Jamnapari X Katjang crossbred
AK = Anglo Nubian X Katjang crossbred

FIG 4.01: BODY WEIGHTS OF FOUR BREED GROUPS OF GOAT AT KLUANG



1.0-4.0 kg in Anglo Nubian x Katjang crossbreds. The coefficients of variation though high were quite similar in the four breed groups.

The Anglo Nubian when crossed with local indigenous Katjang goats recorded a birth weight of 2.50 kg for the male and 2.01 kg for the female with a mean of 2.07 kg. This figure is also lower than that recorded in Malaysia by Paramsothy (1957), and Rajendram and Pillay (1976). Devendra (1962) recorded 2.47 kg for the males and 2.41 kg for the females. The Anglo Nubian when crossed with other native breeds such as Beetal in India (Rana, 1980), Bahamas native (Wilson and Katsigianis, 1980) and Criollo in Mexico (Castillo and Garcia, 1971; Castillo et al., 1972; Garcia et al., 1977; Nolte, 1977) have given much higher birth weights as compared to that of Anglo Nubian x Katjang (AK) of this study.

The Jamnapari purebred (JJ) had higher birth weight as compared to the Anglo Nubian purebred, however, they did not achieve the weights reported in various studies in India by Gill and Dev, (1972), Singh (1973), Singh et al., (1977) and Khan et al., (1979) and others.

The adaptability of the Jamnapari breed was evident in the crossbreds of Jamnapari with Katjang goats by recording higher birth weight (2.21 kg) as compared to the Anglo Nubian x Katjang goats (2.07 kg). The birth weight decreased from 2.25 kg in the 1/2 Jamnapari + 1/2 Katjang crossbred to 2.19 kg in the 15/16 Jamnapari + 1/16 Katjang

crossbred (Table 4.02). However, in the 31/32 Jamnapari + 1/32 Katjang the birth weight was greater than that of the purebred Jamnapari (2.47 vs 2.36 kg respectively).

Duncan's multiple range test showed that there was significant difference between the birth weights of purebred and crossbred Jamnapari where the purebreds were larger at birth compared to crossbreds. However, the weight at one, two and three months (preweaning weights) were similar and not significantly different ($P>0.05$) which most probably were influenced by suckling and maternal environment. Thence on there was a difference between the purebreds and crossbreds which favoured the purebreds. The postweaning weights were statistically significant ($P<0.05$) and the difference between the purebreds and crossbreds ranged from 0.2% at one month to 12.55% at 12 months. The weaning weight and 12 month body weights were also greater in the purebreds as compared to the crossbreds.

4.1.2 Adult weight

In reference to the earlier table (Table 4.01), the weaning and twelve month body weights were greater in the Anglo Nubian purebred. The superiority of purebred Anglo Nubian was evident at weaning and was maintained until year old. The year old body weight of Anglo Nubian purebred was 2.43% more than its cross with Katjang, 40.22% more than that of Jamnapari purebred and 53.19% more than that of Jamnapari x Katjang crossbred. The Jamnapari purebred achieved only 65% of the body weight of Anglo Nubian purebred

Table 4.02: Mean body weights of different grades of Jamnapari x Katjang (JK) goats at Kluang.

Strain	N	Body weight (kg)		
		Bth wt	Weaning wt	Year-old wt
JK_R	818	2.25 ± 0.44^{ab}	8.30 ± 2.08^{b}	16.31 ± 3.43^{ab}
JK_T	1689	2.20 ± 0.47^{b}	8.15 ± 2.19^{b}	15.99 ± 3.63^{b}
JK_U	614	2.19 ± 0.51^{b}	8.16 ± 2.22^{b}	15.70 ± 3.34^{b}
JK_V	331	2.19 ± 0.44^{b}	7.90 ± 2.04^{b}	15.56 ± 3.56^{b}
JK_W	69	2.47 ± 0.44^{a}	8.83 ± 2.27^{a}	17.57 ± 4.28^{a}
Combined	3539	2.21 ± 0.47	8.17 ± 2.16	16.00 ± 3.55

Means with same superscripts in column are statistically not significant ($P<0.05$)

Strain - JK_R = (1/2J + 1/2K)
JK_T = (3/4J + 1/4K)
JK_U = (7/8J + 1/8K)
JK_V = (15/16J + 1/16K)
JK_W = (31/32J + 1/32K)

at year-old.

The year-old weights of the four breed groups were not as high as achieved in temperate countries (Castillo et al., 1972). This lowered performance was possibly due to the stress imposed by the managemental, nutritional and climatological factors as well as the fact that these animals were not selected and also possibly incorporated some stunted animals as well as poorly growing animals or even sickly animals. In spite of the fact that Anglo Nubian breed has Etawah/Jamnapari blood, the supportive size of the Nubian genome was evident. Individually, there were animals that achieved 39 kg but the mean year-old body weight was 24.51 ± 8.74 kg.

It was evident that the introduction of exotic breeds either of the European or Asian origin significantly improved the body weight of the indigenous breed of Malaysia as well as other indigenous breeds (Buvanendran et al., 1974; Singh, 1976; Mishra et al., 1976; Rajendram and Pillay, 1976; Galal and Kebede, 1977; Galal et al., 1977; Chawla and Nath, 1979; Katsigianis et al., 1979; Sengar, 1979; and others).

Analysis of variance performed to determine the variation in the birth weight, weaning weight and year-old weight as influenced by the various factors suggested that year of birth, season, sex, type of kidding, sire breed, dam breed as well as type of progeny had highly significant effect on birth weight. The effect of year of birth and season was highly ($P<0.01$) significant on weaning weight

as well as year-old weight. The effect of sex and type of kidding was highly significant on year-old weight. The breed of sire, breed of dam and breed type of progeny had no effect on weaning weight and yearling weight.

Least square means for main factor effects on birth, weaning and year-old body weights (Table 4.03) illustrated that there was highly ($P<0.01$) significant effect of breed group on birth weight and year-old weights but not on weaning weight. This could be due to the greater percentage of exotic blood in the purebreds. Influence of sex was also highly significant on 6-month weight and on year old-weight.

4.1.3 Correlation between body weights at different ages.

In purebred Anglo Nubian and Anglo Nubian x Katjang crossbreds (Table 4.04) the correlationship between birth weight and subsequent weights was not significant ($P>0.05$), whereas the 3 month, 6 month and 9 month body weights were significantly ($P<0.01$) correlated with 6, 9 and 12 month body weights. In Anglo Nubian purebred the correlation coefficient ranged from 0.36 to 0.99. In the Anglo Nubian x Katjang crossbred the correlation coefficient ranged from -0.07 to 0.97. The greatest relationship was between 9 months and 12 months body weights. It appears that purebred Anglo Nubian and its cross with Katjang cannot be selected for early body weight for a correlated response of body weight at later ages.

Table 4.03: Least square means for main factor effects on birth, weaning and year-old body weight of the four breed groups of goat at Kluang.

Parameter		Birth wt (kg)	Weaning wt (kg)	Year-old wt (kg)
Y (Year of birth)	68	2.23 cd	5.90 a	15.90 ab
	69	2.29 bc	8.33 a	19.18 a
	70	2.21 d	8.00 a	18.98 a
	71	2.39 a	10.05 a	16.70 ab
	72	2.32 b	8.15 a	15.23 ab
	73	2.15 e	7.72 a	13.96 b
	74	2.00 f	6.72 a	16.72 ab
	75	2.07 f	na	na
C (Season)	1	2.24 a	8.25 a	16.24 a
	2	2.25 a	8.63 a	16.61 a
	3	2.20 ab	8.09 a	16.15 a
	4	2.18 b	8.16 a	16.02 a
X (Sex)	Male	2.26 a	8.30 a	17.09 a
	Female	2.18 b	8.27 a	15.75 b
K (Type of kidding)	1	2.26 a	8.29 a	16.33 a
	2	2.11 b	8.29 a	16.05 a
S (Breed of sire)	JJ	2.31 a	8.42 a	16.96 b
	JK	2.18 b	8.24 a	15.67 c
	AA	2.05 c	7.38 a	20.30 a
D (Breed of dam)	AA	2.21 a	9.94 a	24.51 a
	JJ	2.28 a	8.30 a	16.69 b
	JK	2.20 a	8.26 a	16.02 b
	AK	1.80 a	8.44 a	16.09 b
Prog (Type of progeny)	AA	2.19 b	9.94 a	24.51 a
	JJ	2.40 ab	8.38 ab	17.43 b
	JK_R	2.27 ab	8.31 ab	16.31 b
	JK_T	2.20 b	8.37 ab	15.98 b
	JK_U	2.19 b	8.18 ab	15.75 b
	JK_V	2.19 b	7.91 ab	15.57 b
	JK_W	2.46 ab	8.83 a	17.58 b
	AK_T	2.70 a	na	na
	AK_R	2.03 b	6.18 b	16.09 b

, b, c Same superscripts in column for each variable are statistically not significant (P>0.05).

Breeds groups: AA=Anglo Nubian purebred
JJ=Jamnapari purebred
AK=Anglo Nubian x Katjang crossbred
JK=Jamnapari x Katjang crossbred
JK_R= 1/2J + 1/2K
JK_T= 3/4J + 1/4K
JK_U= 7/8J + 1/8K
JK_V= 15/16J + 1/16K
JK_W= 31/32J + 1/32K

Table 4.04: Correlation coefficients of body weights at different ages for purebred and crossbred goats at Kluang.

Breed	Variable	3 mth wt	6 mth wt	9 mth wt	12 mth wt
AA	Birth wt	0.38	0.36	0.55	0.60
	3month wt		0.96**	0.92**	0.96**
	6month wt			0.99**	0.99**
	9month wt				0.99**
JJ	Birth wt	0.25**	0.22**	0.20*	0.35**
	3month wt		0.71**	0.62**	0.53**
	6month wt			0.89**	0.73**
	9month wt				0.89**
JK	Birth wt	0.14**	0.23**	0.15**	0.12**
	3month wt		0.30**	0.22**	0.16**
	6month wt			0.81**	0.70**
	9month wt				0.86**
AK	Birth wt	0.04	-0.07	0.02	0.06
	3month wt		0.93**	0.71*	0.67*
	6month wt			0.94**	0.88**
	9month wt				0.97**

* Significant at (P<0.05)
** Significant at (P<0.01)

Breeds: AA = Anglo Nubian purebred
JJ = Jamnapari purebred
JK = Jamnapari X Katjang crossbred
AK = Anglo Nubian X Katjang crossbred

The correlation coefficient between birth weight and 3 month, 6 month, 9 month and 12 month body weight was highly significant ($P<0.01$) in Jamnapari and Jamnapari x Katjang crossbred goats. It suggests that in these breed groups heavier kids at birth would be able to retain their advantage beyond weaning.

When the males and females were analysed separately it was found that the correlation between birth weight and subsequent body weights in male Anglo Nubian kids were all positive and significant (Table 4.05). The insufficient number of female kids failed to show any relationship between the 9 month and year old weights in the Anglo Nubian purebreds.

The correlation coefficients are very variable between the sexes in both the purebred Anglo Nubian and Anglo Nubian x Katjang crossbred. The relationship was positive in some males and negative in some females. The weaning weight and subsequent body weights are strongly related ($P<0.01$) and could be used for predicting yearling weight in Anglo Nubian Katjang crossbreds. The females can be selected as early as after weaning whereas the male kids will have to be selected later (after 6 months) when they begin to show their sexual prowess as they attain sexual maturity.

In breed groups possessing Anglo Nubian genome (AA and AK) the birth weight was not correlated to subsequent body weights except in the purebred Anglo Nubian males indicating that birth weight cannot be used as a parameter

Table 4.05: Correlation coefficients of body weights at different ages for purebred and crossbred Anglo Nubian at Kluang.

Breed	Sex	Variable	3 mth wt	6 mth wt	9 mth wt	12 mth wt
AA	M	Birth wt	0.89**	0.80*	0.76*	0.83*
		3month wt		0.97**	0.93**	0.96**
		6month wt			0.99**	0.99**
		9month wt				0.99**
	F	Birth wt	0.07	0.10	na	na
		3month wt		0.97**	na	na
		6month wt			na	na
		9month wt				na
AK	M	Birth wt	0.30	0.36	-0.37	-0.32
		3month wt		0.92**	0.73	0.68
		6month wt			0.93**	0.90*
		9month wt				0.98**
	F	Birth wt	-0.12	-0.41	-0.15	-0.56
		3month wt		0.95**	0.95**	0.91
		6month wt			0.99**	0.93
		9month wt				0.93

* Significant at P<0.05
** Significant at P<0.01

Breeds: AA = purebred Anglo Nubian
AK = Anglo Nubian X Katjang crossbred

Sex : M = Male
F = Female

for selection of body weights at later stage. Selection on these two breed groups will have to depend on weaning weight or subsequent body weights.

The influence of the dam breed was quite evident in the Anglo Nubian x Katjang crossbred goats. The correlation between birth weight and subsequent body weights in Anglo Nubian x Katjang females were all negative and non-significant ($P>0.05$) whereas in the males the relationship was low and positive between birth and 3 and 6 months and low and negative between birth and 9 and 12 months. In the Anglo Nubian crossbred kids the greatest relationship was between 9 and 12 months in the males and between 3, 6, 9 and 12 months in the females. This suggests that the female kids can be selected as early as after weaning whereas the male kids will have to be selected later (after 6 months).

The correlation coefficient between body weights at various ages for different Jamnapari grades are presented in Table 4.06 with sexes combined and in Table 4.07 with the sexes separated. It was observed that the birth weight was significantly correlated to 3, 6 and 9 month body weights in strains containing 1/2 Jamnapari + 1/2 Katjang breed, 3/4 Jamnapari + 1/4 Katjang, 7/8 Jamnapari + 1/8 Katjang and 15/16 Jamnapari + 1/16 Katjang. In 31/32 Jamnapari + 1/32 Katjang genome the correlation between birth weight and 3, 6, 9, and 12 month body weights was statistically non-significant. It suggests that in these breed groups kids with heavier birth weights would be able to retain their advantage

Table 4.06 : Correlation between body weights at different ages for different grades of Jamnapari goats at Kluang.

Breed	Variable	3 mth wt	6 mth wt	9 mth wt	12 mth wt
JK_R	Birth wt	*** (328)	*** (278)	*** (229)	ns (163)
	3 mth wt	-	*** (279)	*** (230)	*** (164)
	6 mth wt		-	*** (229)	*** (163)
	9 mth wt			-	*** (164)
JK_T	Birth wt	** (847)	*** (737)	* (600)	ns (403)
	3 mth wt		*** (749)	*** (603)	** (407)
	6 mth wt			*** (603)	*** (407)
	9 mth wt				*** (405)
JK_U	Birth wt	*** (226)	*** (206)	* (166)	* (111)
	3 mth wt		*** (205)	*** (164)	*** (111)
	6 mth wt			*** (166)	*** (111)
	9 mth wt				*** (108)
JK_V	Birth wt	*** (116)	** (102)	* (88)	ns (58)
	3 mth wt		*** (101)	*** (86)	*** (58)
	6 mth wt			*** (85)	*** (58)
	9 mth wt				*** (57)
JK_W	Birth wt	ns (20)	ns (19)	ns (16)	ns (11)
	3 mth wt		*** (19)	ns (16)	ns (11)
	6 mth wt			*** (16)	** (11)
	9 mth wt				*** (10)

ns not significant (P>0.05). ( ) number of observations.
* Significant (P<0.05)
** Significant (P<0.01)
*** Significant (P<0.001)

Table 4.07: Correlation coefficients of body weights at different ages for various grades male and female Jamnapari crossbreds at Kluang.

Breed	Sex	Variable	3month wt	6month wt	9month wt	12month wt
JK_R	M	Birth wt	+*	+ns	+**	+ns
		3month wt		+**	+**	+**
		6month wt			+**	+**
		9month wt				+**
	F	Birth wt	+**	+**	+*	+*
		3month wt		+**	+**	+**
		6month wt			+**	+**
		9month wt				+**
JK_T	M	Birth wt	+**	+**	+ns	+ns
		3month wt		+**	+**	+**
		6month wt			+**	+**
		9month wt				+**
	F	Birth wt	+ns	+**	+ns	+ns
		3month wt		+**	+**	+**
		6month wt			+**	+**
		9month wt				+**
JK_U	M	Birth wt	+**	+**	+*	+ns
		3month wt		+**	+**	+**
		6month wt			+**	+**
		9month wt				+**
	F	Birth wt	+**	+*	+ns	+ns
		3month wt		+**	+**	+**
		6month wt			+**	+**
		9month wt				+**
JK_V	M	Birth wt	+**	+*	+ns	+ns
		3month wt		+**	+**	+**
		6month wt			+**	+**
		9month wt				+**
	F	Birth wt	+*	+ns	+ns	-ns
		3month wt		+**	+**	+ns
		6month wt			+**	+**
		9month wt				+**
JK_W	M	Birth wt	+ns	+ns	+ns	+ns
		3month wt		+*	+ns	+ns
		6month wt			+**	+**
		9month wt				+**
	F	Birth wt	-ns	-ns	-ns	-ns
		3month wt		+**	+**	+ns
		6month wt			+**	+ns
		9month wt				+ns

* Significant at P<0.05, ** Significant at P<0.01
ns Not significant; Sex: M = Male, F = Female;
Breeds: JK_R = Jamnapari X Katjang (1/2 + 1/2)
JK_T = Jamnapari X Katjang (3/4 + 1/4)
JK_U = Jamnapari X Katjang (7/8 + 1/8)
JK_V = Jamnapari X Katjang (15/16 + 1/ 16)
JK_W = Jamnapari X Katjang (31/32 + 1/32)

beyond weaning.

The best simple and multiple regression equations for predicting year-old weight based on birth and weaning weights in purebred and crossbred goats are also presented in Table 4.08. For each purebred and crossbred groups there is a separate value for each equation (simple regression: Y=a+bW and the multiple regression: Y=a+bW+cB).

4.1.4 Body measurements

The phenotypic body measurements of some breed groups of Asian goats are presented in Table 4.09. Variation in body size is one of the criteria used in classifying breeds of goat (Devendra and Burns, 1983). Besides the body weight, morphometric measurements or phenotypic body measurements are also of value in identifying the quantitative characteristics of meat as well as helpful in developing selection criteria (Bose and Basu, 1984; Sarma et al., 1984; Islam et al., 1991; Mohammed and Amin, 1996). Body measurements have been used to predict body weight in a number of goat breeds (Valdez et al., 1982; Bhattacharya et al., 1984; Mukherjee et al., 1986; Singh et al., 1987; Mittal, 1988; Tizikara and Chiboku, 1988; Mohammed and Amin, 1996).

In the present study the advantage of male over female was statistically significant and was evident in most body measurements (Table 4.10). Similar observations were also made by Nishida and Hayashi (1972). There was significant difference ($P<0.05$) between the body measurements

Table 4.08: Simple and multiple regression for predicting year-old weight based on birth and weaning weights in purebred and crossbred goats at Kluang.

Breed	Simple regression	R^2	Multiple regression	R^2
AA	Y=5.1217+1.4627WW	0.9603	Y=-0.8863+3.3759WW +3.3759BW	0.9723
AK	Y=3.0090+1.6327WW	0.5441	Y=-8.5789+1.7776WW +4.7637BW	0.6086
JJ	Y=8.7417+0.8841WW	0.3813	Y= 6.1773+0.8065WW +1.4051BW	0.4141
JK_R	Y=9.1490+0.7501WW	0.1979	Y= 9.1984+0.7521WW -0.0294BW	0.1979
JK_T	Y=7.5234+0.9061WW	0.3128	Y= 8.3885+0.9298WW -0.4882BW	0.3157
JK_U	Y=8.4229+0.7596WW	0.3248	Y= 7.9185+0.7455WW +0.2787BW	0.3260
JK_V	Y=4.1354+1.2514WW	0.4470	Y= 5.9475+1.3401WW -1.1463BW	0.4651
JK_W	Y=7.9189+1.0080WW	0.2761	Y= 2.9426+1.0151WW +4.5370BW	0.4547

Variable: Y = Year old weight
WW = Weaning Weight
Bw = Birth Weight

Breed: AA = Anglo Nubian purebred
AK = Anglo Nubian x Katjang crossbred
JJ = Jamnapari purebred
JK_R = Jamnapari x Katjang (1/2 + 1/2)
JK_T = Jamnapari x Katjang (3/4 + 1/4)
JK_U = Jamnapari x Katjang (7/8 + 1/8)
JK_V = Jamnapari x Katjang (15/16 + 1/16)
JK_W = Jamnapari x Katjang (31/32 + 1/32)

le 4.09: Range of body measurements of some breed groups of goat in Asia

ed up	Adult weight (kg)	Wither height (cm)	Body length (cm)	Chest girth (cm)	References
o Nubian	65.00-80.00	80.0-90.0			Ann. Rep. DVS., 1986
ra	25.72-33.70	59.61	69.96	80.15	Patil, 1992
ari	22.56-37.84	56.20-70.50	58.70-70.50	68.30-75.50	Acharya, 1982
al	84.92-89.07	77.10-91.60	80.30-85.50	73.00-86.00	Acharya, 1982
al	20.38-32.37	55.40-58.30	51.20-63.30	63.20-72.00	Acharya, 1982
lpine	65.00-80.00	80.00-90.00			Ann. Rep. DVS., 1986
	25.71-39.42	60.00-68.60	69.30-75.80	60.50-80.70	Acharya, 1982
	24.72-27.45	58.10-61.30	65.20-69.50	69.30-72.20	Acharya, 1982
n	31.87-44.05	77.10-84.50	67.60-76.00	74.60-83.10	Acharya, 1982
wadi	36.03-37.10	79.50-81.20	72.40-73.40	74.70-75.20	Acharya, 1982
pari	38.03-44.66	75.20-78.20	75.20-77.40	76.10-79.50	Acharya, 1982
ana	44.48-51.80	79.10-90.40	77.70-84.10	68.60-86.00	Acharya, 1982
i	28.62-35.76	76.20-84.10	67.30-71.10	70.80-77.50	Acharya, 1982
ng	25.00-30.00	55.00-65.00	60.00-70.00	65.00-75.00	Ann. Rep. DVS., 1986
	39.29-43.50	82.40-86.40	75.00-77.10	75.40-76.10	Acharya, 1982
ri	31.12-38.96	63.20-71.90	63.50-70.20	67.40-73.80	Acharya, 1982
i	25.85-33.18	69.30-74.70	53.50-61.00	68.60-71.20	Acharya, 1982
a	32.39-37.14	74.30-80.40	68.00-71.20	73.00-76.90	Acharya, 1982
badi	32.36-33.66	74.80-77.90	67.50-69.10	72.00-72.10	Acharya, 1992
	65.00-85.00	80.00-90.00			Ann. Rep. DVS., 1986
negri	28.97-38.37	68.00-77.30	62.50-69.80	71.00-76.00	Acharya, 1982
	22.54-50.37	68.40-85.60	61.30-80.00	62.40-80.00	Acharya, 1982
	32.03-29.50	70.10-73.50	65.00-66.60	70.50-71.80	Acharya, 1982
urg	60.00-75.00	70.00-85.00			Ann. Rep. DVS., 1986

Table 4.10: Phenotypic correlation between body weight and body measurements at 6 and 12 months of age.

	Katjang x Katjang		Jamnapari x Katjang	
Variable	6 mth	12 mth	6 mth	12 mth
Height (cm)	0.33ns	0.25ns	0.86 ***	0.81 ***
Girth (cm)	0.33ns	0.09ns	0.91 ***	0.91 ***
Length (cm)	0.42 *	0.32ns	0.93 ***	0.89 ***
Cannon (cm)	0.43 *	0.61 **	0.83 ***	0.64 ***
Tibia (cm)	-0.13ns	-0.05ns	0.65 ***	0.47 ***
Hook (cm)	-0.25ns	0.08ns	0.79 ***	0.81 ***
Loin (cm)	0.29ns	0.22ns	0.77 ***	0.72 ***
Head (cm)	-0.15ns	-0.18ns	0.33 **	0.04ns
Pinbone - Hock (cm)	0.45 *	0.35ns	0.82 ***	0.74 ***

* = significant at 5% level
** = significant at 1% level
*** = significant at 0.1% level
ns = not significant at 5% level

of purebred Katjang and Jamnapari crossbreds. The increment between the 6 month body measurements and the 12 month body measurements was also highly significant. The difference between the two breed groups at 12 months of age suggested an increment of as much as 33.87%.

The phenotypic correlation between weight and wither height, chest girth, body length, shank length, rump and loin was statistically not significant in male and female goats. In the Jamnapari x Katjang crossbred goats the correlation coefficient of body weight was greatest with body length ($P<0.01$; $r=0.93$) and chest girth ($P<0.01$; $r=0.91$) which was assumed natural because the major body weight is due to these two portions of the body. Positive and significant correlation of body weight with body measurements were also reported by Tandon (1966) in the Beetal, Singh et al., (1979) in Black Bengal and Mukherjee (1978) in Brown Bengal and Grey Bengal goats of India.

Using cannon length as the independent variable, body weight of Katjang goats at 12 months of age could be estimated using the equation $Y=7.80X_4-52.77$ where Y is estimated weight and X_4 is the cannon length (Table 4.11). In the Jamnapari x Katjang crossbred goats the 12 month body weight could be estimated using the equation $Y=1.72X_2-62.97$ where Y is as above and X_2 is chest girth. Chest girth was the best single determinant for estimating the weight of the goat in agreement with Valdez et al., (1982). The multiple regression analysis showed that the coefficient of

Table 4.11:Prediction equations of body weight with the help of one variable in purebred and crossbred Katjang goats at Kluang.

Breed group	Age (mth)	Regression equation Y = a+bX	F	R^2
Katjang x Katjang	6	$Y = -17.77+2.22X_9$	6.04	0.2009*
	12	$Y = -52.78+7.80X_4$	11.20	0.3708**
Jamnapari x Katjang	6	$Y = -36.44+1.31X_3$	434.93	0.8562***
	12	$Y = -62.97+1.72X_2$	320.81	0.8208***

Where Y = estimated weight in kilograms
a = intercept
b = regression coefficient
X_9 = distance between pinbone to point of hock
X_4 = length of cannon
X_3 = body length
X_2 = chest girth
* = significant at 5% level
** = significant at 1% level
*** = significant at 0.1% level

determination (R^2) values tend to increase as the number of measurements taken is increased (Table 4.12). The R^2 values for 12 month body weight in Katjang and Jamnapari x Katjang crossbreds increased from 0.37 to 0.70 and 0.80 to 0.90 respectively.

4.1.5 Average Daily Gain (ADG)

The unadjusted preweaning and postweaning ADG (average daily gain) in the four breed groups were as presented in Table 4.13. The purebred Anglo Nubian had the best growth (78.81 gm/day) among the four breed groups. The adjusted preweaning and postweaning ADG of the purebred Anglo Nubian was 85.95 and 48.18 gm/day respectively. It was noted that the Anglo Nubian x Katjang cross though had poorer growth rate prior to weaning, it demonstrated an improved growth postweaning.

Birth weight had an effect on ADG for the first two months only (Panandam, 1992) as opposed to Singh (1962) who found no relationship between birth and gain in 1st, 2nd and 3rd months.

The annual adjusted ADG was 62.82 and 38.96 gm/day in Anglo Nubian and Anglo Nubian x Katjang as compared to 42.93 and 39.26 gm/day in purebred Jamnapari and Jamnapari x Katjang crossbred respectively. The superiority of Anglo Nubian over Jamnapari was 46.23%, over Jamnapari x Katjang was 60.01% and over Anglo Nubian x Katjang was 61.24%. It was also observed that the purebreds had better growth as

Table 4.12: Prediction equations of body weight with the help of nine variables in purebred and crossbred Katjang goats at Kluang.

Breed group	Age (mth)	Regression equation $Y = a+b_1X_1+b_2X_2...b_n X_n$	R^2
Katjang x Katjang	6	$Y = -12.37+0.70X_1+0.61X_2 -0.83X_3+2.17X_4+1.84X_5 -10.87X_6 +10.97X_7-6.08X_8 +0.68X_9$	0.7974***
	12	$Y = -27.77+0.94X_1+0.10X_2 +0.57X_3+10.88X_4-7.69X_5 +5.96X_6-7.13X_7-0.50X_8 +2.14X_9$	0.7016ns
Jamnapari x Katjang	6	$Y = -42.95-0.28X_1+0.75X_2 +0.75X_3+1.10X_4+0.03X_5 -1.07X_6-0.77X_7-0.29X_8 +0.71X_9$	0.9364***
	12	$Y = -65.13+0.64X_1+0.79X_2 +0.65X_3+0.26X_4-0.79X_5 +1.21X_6-0.61X_7-1.16X_8 +0.13X_9$	0.8953***

Where Y = estimated weight in kilograms
a = intercept
b_1 b_2...b_n = regression coefficient
X_1 = wither height
X_2 = chest girth
X_3 = body length
X_4 = length of cannon
X_5 = length of tibia
X_6 = width of hook area
X_7 = width of loin area
X_8 = breadth of head
X_9 = pinbone to hock
* = significant at 5% level
** = significant at 1% level
*** = significant at 0.1% level

Table 4.13: Pre-weaning and post-weaning average daily gain (ADG) for the purebred and crossbred goats at Kluang

Breed group	Preweaning		Postweaning		Birth to Year old	
	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.
AA	78.81$_a$	85.95$_a$	46.13$_a$	48.18$_a$	61.22$_a$	62.82$_a$
JJ	62.56$_b$	70.35$_b$	31.00$_b$	32.84$_b$	41.40$_b$	42.93$_b$
JK	59.23$_b$	67.77$_b$	27.02$_b$	28.91$_b$	37.70$_b$	39.26$_b$
AK	42.69$_c$	46.51$_c$	33.11$_b$	34.41$_b$	38.08$_b$	38.96$_b$

Means with same subscripts in column are statistically not different (P>0.05)

Breeds: AA = Anglo Nubian purebred
JJ = Jamnapari purebred
JK = Jamnapari X Katjang crossbred
AK = Anglo Nubian X Katjang crossbred

compared to the crossbreds by 61.24% in Anglo Nubian and 9.35% in Jamnapari.

It was apparent that 3/4 and 7/8 crosses of Jamnapari x Katjang gave best weight gain. Among the males the 3/4 Jamnapari cross gave the highest weight gain of 1.78 kg, whereas in the females the 7/8 crosses gave the highest weight gain of 1.64 kg. As the blood of Jamnapari increased from 1/2 to 15/16, the weight gain gradually reduced contrary to expectations until the genetic ratio was 31/32 for Jamnapari/Katjang.

The growth of the males was greater than females and increased with age (Amble et al., 1964; Mishra et al., 1978; Malick et al., 1986 and Panandam 1990). However, Panandam (1990) found that at first, second, fourth and fifth months, the females recorded higher ADG though the difference between sexes was not significant.

The purebred Jamnapari and the 15/16 cross gave comparatively high birth weights and encouraging body weight gain. Based on some of the earlier results from the Department of Veterinary Services, the variation in the performance of the Jamnapari x Katjang is more due to individual performance rather than breed characteristics.

The greatest weight gain was during preweaning or suckling period. The excess milk consumed by the single as compared to multiple births resulted in better growth in singles (Mittal and Pandey, 1978; Ehoche and Buvanendran, 1983). Following weaning there was an initial drop in the

weight gain, followed by an increase in growth rate of the multiple births as if to compensate for their suppressed growth during pre-weaning. After the fifth month the goats gained again as they got used to the fodder provided, however, the effect of weaning was quite pronounced. The post-weannng ADG was increased with increased intake of concentrate and fodder as reported by Guha et al., (1968). Another drop in body weight gain was noticed at about the 8th month but it was not as severe as the one at weaning. Such a phenomenon was observed every year.

The values reported in this study are quite low compared to those obtained from other countries which is evidently due to the climatological, nutritional and managemental stress. Temperature together with humidity play an important role. The deficiency of forage and well balanced rations at time of body growth significantly influences the growth of the animals.

4.1.6 Growth Pattern

The rate of growth is measured either in gm/day or kg/wk or gm/wk. The rate of growth at different ages are presented in Tables 4.14, 4.15 and 4.16. The growth rates presented are the Average Absolute Growth Rate (AAGR) calculated using Hays and Armstrong's formula, the Average Relative Growth Rate (ARGR) using Minot's modified formula and the Instantaneous Relative Growth Rate (IRGR) using Brody's formula.

Gain in weight during the suckling period was greatest in Anglo Nubian purebred (254.57 gm/day) and lowest in Anglo Nubian x Katjang breed group (134.96 gm/day). There was not much of a difference between 196.94 gm/day in Jamnapari purebred and 199.44 gm/day in the Jamnapari x Katjang crossbreds. The post-weaning growth rate in Anglo Nubian purebred went down to 46.14 gm/day in the 5th month which often happens when kids are weaned and they are getting used to the new feed and fodder. The growth rate then improved to the third quarter (9th month) after which it plateaued out to year old. This also coincided with the monsoons.

Due to the dry period in the months of August and September there is shortage of feed in the months of October, November and December. The shortage of feed supply is exagerated by the monsoon rains in November and December when the animals cannot be grazed and are kept indoors for most of the time. The fodder provided is often limited which

Table 4.14: Average Absolute Growth Rate (AAGR) of goats at Kluang

Month	Breeds			
	AA	JJ	JK	AK
1	103.98	77.59	85.56	46.36
2	77.99	65.79	61.34	48.01
3	72.60	53.56	52.54	40.59
4	61.12	52.89	37.58	31.68
5	46.14	40.57	38.09	37.21
6	48.48	37.40	32.01	39.81
7	56.67	32.86	30.20	52.59
8	67.79	34.96	25.68	53.72
9	75.28	25.20	22.82	26.75
10	40.07	20.82	21.29	27.71
11	39.34	19.96	18.82	35.17
12	42.99	31.74	26.08	20.20

Hayes and Armstrong's formula:

$$k = \frac{W2 - W1}{t2 - t1} = gm$$

Breeds group: AA = Anglo Nubian purebred
JJ = Jamnapari purebred
JK = Jamnapari X Katjang crossbred
AK = Anglo Nubian X Katjang crossbred

Table 4.15: Average Relative Growth Rate (ARGR) of goats at Kluang

Month	Breeds			
	AA	JJ	JK	AK
1	317.14	236.67	260.99	141.41
2	237.86	200.68	187.10	146.45
3	221.43	163.36	160.26	123.81
4	186.43	161.32	114.65	96.64
5	140.71	123.77	116.20	113.51
6	147.86	114.10	97.64	121.44
7	172.86	100.24	92.13	160.42
8	206.75	106.66	78.34	163.85
9	229.60	76.86	69.63	81.61
10	122.22	63.53	64.94	84.55
11	120.00	60.88	57.42	107.27
12	131.11	96.83	79.57	61.62

Minot's modified formula:

$$k = \frac{W2 - W1}{t2 - t1} \times 100 = \quad \%$$

Breeds group: AA = Anglo Nubian purebred
JJ = Jamnapari purebred
JK = Jamnapari X Katjang crossbred
AK = Anglo Nubian X Katjang crossbred

Table 4.16: Instantaneous Relative Growth Rate (IRGR) of four breedgroups of goat at Kluang.

Month	Breeds			
	AA	JJ	JK	AK
1	90.04	68.92	77.79	52.19
2	36.82	35.23	32.76	35.15
3	25.21	21.65	21.45	22.36
4	17.20	17.58	12.94	14.53
5	11.27	11.66	11.60	14.74
6	10.61	9.67	8.80	13.68
7	11.13	7.78	7.65	15.61
8	11.86	7.67	6.08	13.77
9	11.71	5.18	5.11	6.21
10	5.72	4.09	4.54	6.05
11	5.31	3.77	3.84	7.19
12	5.50	5.71	5.10	3.91

Brody's formula:

$$k = \frac{\ln W2 - \ln W1}{t2 - t1} \times 100 = \quad \%$$

Breeds group: AA = Anglo Nubian purebred
JJ = Jamnapari purebred
JK = Jamnapari X Katjang crossbred
AK = Anglo Nubian X Katjang crossbred

resulted in poor growth rate, and sometimes to the extent of negative growth rate.

The above phenomenon was quite evident in Anglo Nubian purebred and Anglo Nubian x Katjang crossbred (Figure 4.02) whereas in the Jamnapari purebred and Jamnapari x Katjang crossbreds the trend as depicted by the average relative growth rate was slightly different in that the growth rate gradually reduced to about the 11th month (Figure 4.03). At the 12th month the growth rate improved in all breed groups except Anglo Nubian x Katjang crossbred. As the study was done only until the 12th month and no information was available on the subsequent growth, it was difficult to determine whether the trend describes increasing or decreasing growth rate beyond the 12th month. Therefore, it is suggested that further studies be conducted possibly to 24 or 48 months of age to illustrate the growth pattern.

The Instantaneous Relative Growth Rates in percentage are presented in Figure 4.04. It was observed that the growth rate decreased with time and was positive. A slight fluctuation occured at the 7th and 8th months in Anglo Nubian x Katjang crossbred and at the 9th month in Anglo Nubian purebred. The fluctuations depicted the growth cycles. It was also noticed that the rate of growth was significantly affected by breed group during the younger age which was probably due to the maternal genetic effect. Although the difference between breeding groups was not significant during the later life, the growth rate of the

FIG 4.02: AVERAGE ABSOLUTE GROWTH RATE OF FOUR BREED GROUPS OF GOAT AT KLUANG

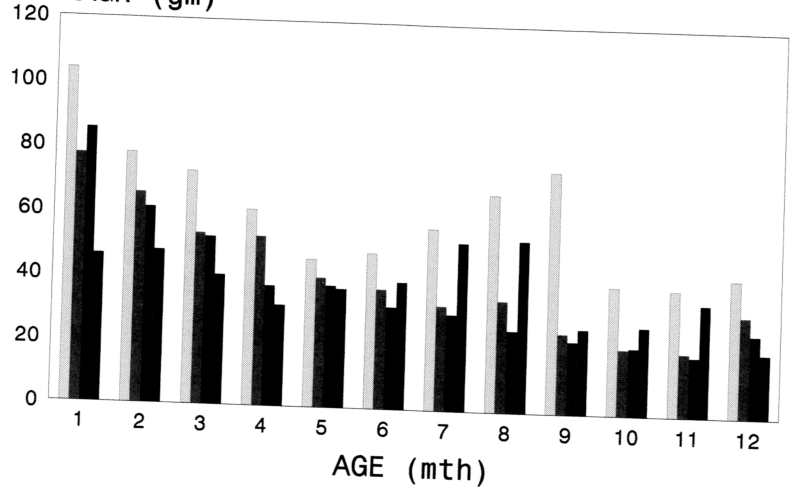


FIG 4.03: AVERAGE RELATIVE GROWTH RATE OF FOUR BREED GROUPS OF GOAT AT KLUANG

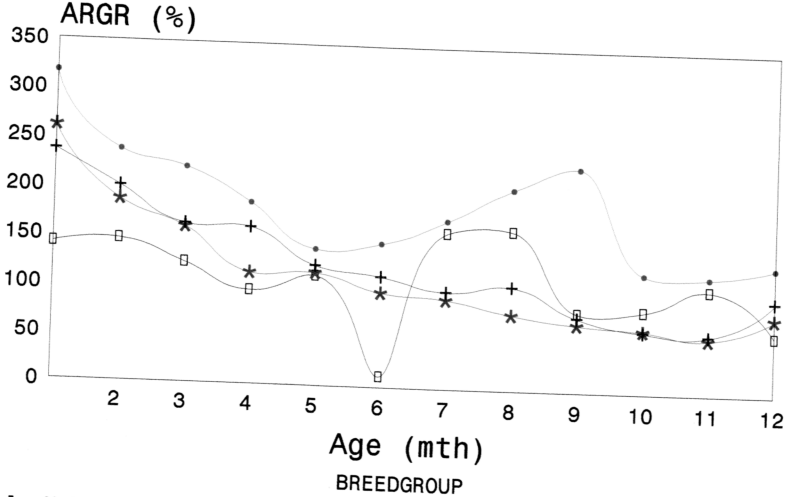
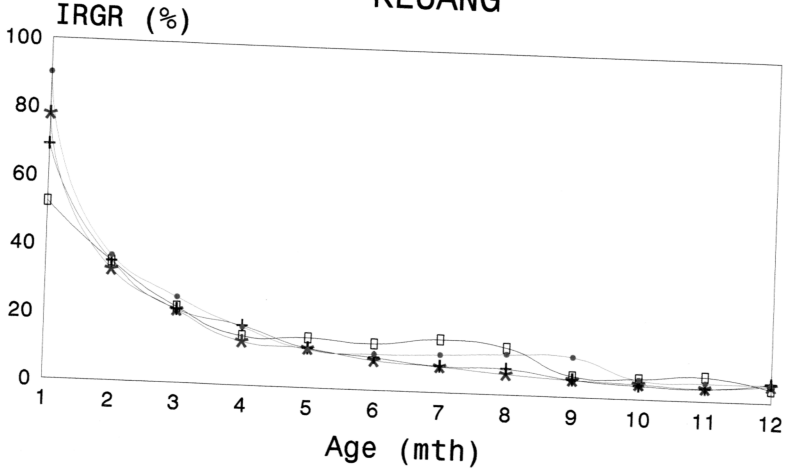


FIG 4.04: INSTANTANEOUS RELATIVE GROWTH RATE OF FOUR BREED GROUPS OF GOAT AT KLUANG



local kids was enhanced by the introduction of the exotic genes.

The growth rate of males was greater than that of females and increased with age as reported by Amble et al., (1964), Mishra et al., (1978), Malick et al., (1986) and Panandam (1990). However, the trend was similar in both sexes.

The trend of the growth rates were compared for each breed group using the three formulae (Hays and Armstrong's formula, Minot's modified formula and Brody's formula) and are presented in Figures 4.05, 4.06, 4.07 and 4.08. Although all the three formulae could be used to demonstrate the growth pattern of the goats, it appeared that the Minot's formula better illustrated the growth rate of the above breed groups.

The regression equations to show the trend in growth curves for the four breed groups were highly significant ($P<0.01$) and ranged from 0.53 in Anglo Nubian purebred to 0.72 in Anglo Nubian x Katjang crossbred (Table 4.17. The regression equations determined for the growth rates were $Y = 51.45 - 4.81X$, $Y = 43.33 - 4.12X$, $Y = 44.54 - .38X$ and $Y = 38.47 - 3.29X$ for Anglo Nubian purebred, Jamnapari purebred, Jamnapari x Katjang crossbred and Anglo Nubian x Katjang crossbred respectively, where Y is the growth rate and X is the age.

The coefficient of determination (R^2) were calculated as the ratio of sum of squares due to the

FIG 4.05: COMPARATIVE TREND OF GROWTH RATES FOR ANGLO NUBIANS

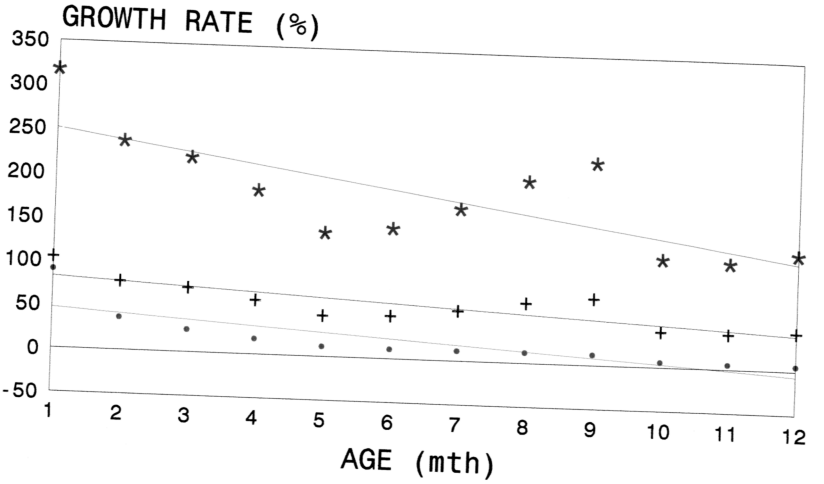


FIG 4.06: COMPARATIVE TREND OF GROWTH RATES OF JAMNAPARI

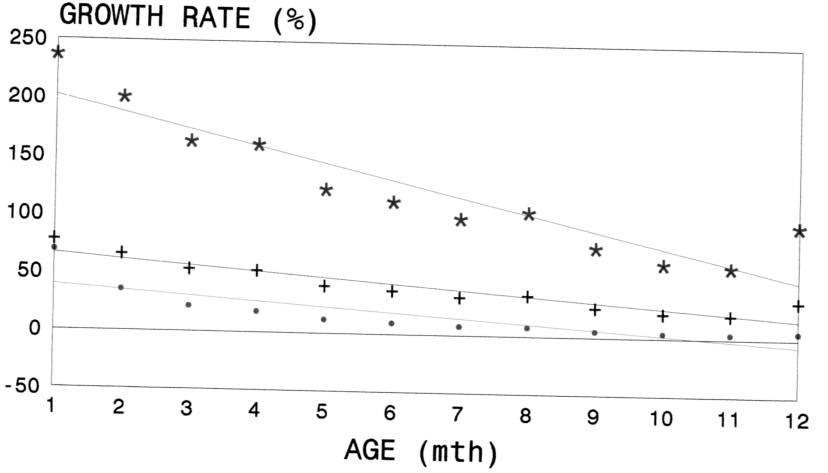


FIG 4.07: COMPARATIVE TREND OF GROWTH RATES FOR ANGLO NUBIAN X KATJANG

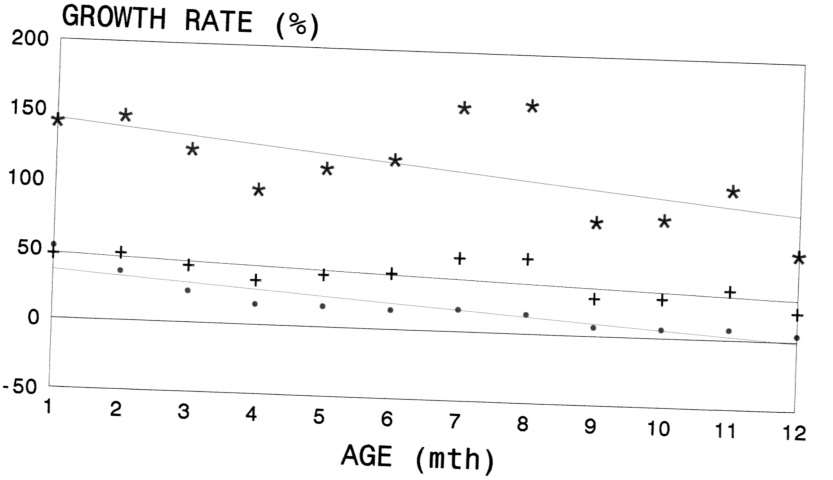


FIG 4.08: COMPARATIVE TREND OF GROWTH RATES OF JAMNAPARI X KATJANG

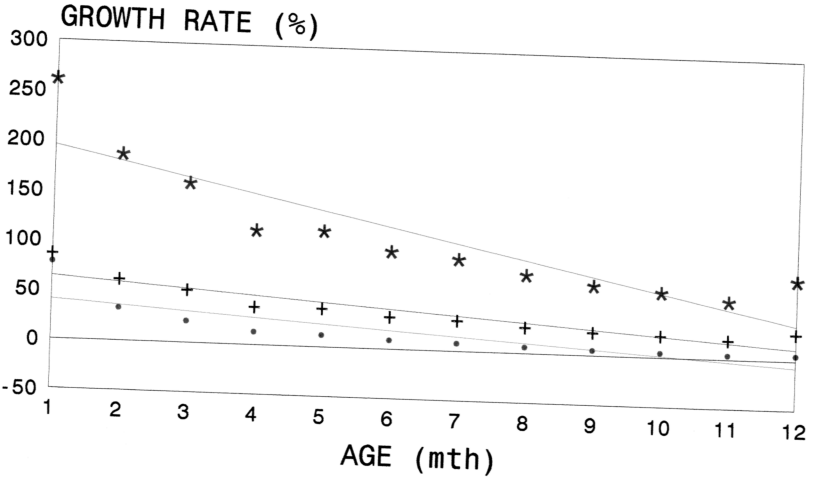


Table 4.17: Regression equation to show the trend in growth rates for purebred and crossbred goats at Kluang

Breed	Regression equation Y = a + bX	F-value	R^2
AA	Y = 51.45 - 4.81X	11.30	0.53**
JJ	Y = 43.33 - 4.12X	16.28	0.62**
JK	Y = 44.54 - 4.38X	11.99	0.55**
AK	Y = 38.47 - 3.29X	26.08	0.72**

Y = Body weight X = Age

* Significant at P<0.05
** Significant at P<0.01

Breeds: AA = Anglo Nubian purebred
JJ = Jamnapari purebred
JK = Jamnapari X Katjang crossbred
AK = Anglo Nubian X Katjang crossbred

dependent variable. The partial coefficients were tested for their statistical significance by students "t" test and were found to be highly significant ($P<0.01$).

4.1.7 Comparative growth performance in some breed groups of goat as demonstrated in a trial at Kluang.

4.1.7.1 Birth weight

The mean birth weight of single and twin kids from Anglo Nubian x Katjang dams ranged from 2.66 to 2.98 kg and those kids from the Jamnapari x Katjang does ranged from 2.72 to 2.58 kg (Table 1.18). It was observed that the twin kids (2 males or 2 females) were heavier in Jamnapari x Katjang crossbred does compared to Anglo Nubian x Katjang kids. However, in twins where the kids were 1 male and 1 female the birth weight of the kids born was slightly heavier in Anglo Nubian x Katjang crossbred dams compared to those from Jamnapari x Katjang dams. In single births the male kids were heavier than the females by 12.03% in Anglo Nubian x Katjang and 8.09% in Jamnapari x Katjang does respectively. There was no significant difference (P>0.05) between the two breed groups.

The birth weight of male kids from Anglo Nubian x Katjang and Jamnapari x Katjang does was similar (2.94 and 2.98 kg). The female Jamnapari x Katjang kids were slightly heavier than Anglo Nubian x Katjang female kids (2.72 and 2.66 kg) which were comparable to that recorded by Belinchos and Marques (1971). The variation in birth weight due to type of birth and sex was evident as reported by Singh (1978) and Amble et al., (1964).

Table 4.18: Mean (±S.E.) of birth weights of a sample of kids in different types of litters.

Type of birth	Sex	Breed of dam	Mean ± S.E.
Twin	2 males	AK	4.88 ± 0.35
		JK	4.94 ± 0.22
	2 females	AK	5.29 ± 0.28
		JK	5.41 ± 0.24
	1 male + 1 female	AK	5.31 ± 0.17
		JK	5.15 ± 0.18
Single	male	AK	2.98 ± 0.15
		JK	2.94 ± 0.10
	female	AK	2.66 ± 0.15
		JK	2.72 ± 0.09

Dam breeds: AK = Anglo Nubian x Katjang

JK = Jamnapari x Katjang

The incidence of occurance of all female kids in any conception was 24.24% in Anglo Nubian x Katjang does and 29.17% in Jamnapari x Katjang does. The incidence of occurance of all male kids in the conceptus was 27.03% in Anglo Nubian x Katjang and 28.57% in Jamnapari x Katjang. The incidence of occurance of 1 male + 1 female was 48.65% in Anglo Nubian x Katjang and 49.35% in Jamnapari x Katjang breed groups respectively. There was no significant difference ($P>0.05$) between the two breed groups.

The mean body weight at birth, weaning and 12 months old for the four breedgroups of goats are presented in Table 4.19. The mean birth weight of S(AK) breedgroup was 2.90 ± 0.97 kg as compared to 2.57 ± 0.86 kg in the AK breedgroup and 2.70 ± 0.56 kg in the S(JK) breedgroup as compared to 2.60 ± 0.57 kg in the JK breedgroup. These birth weights were greater than that recorded by Paramsothy (1957), Shalash et al. (1970), Gonzalez (1974), Rajendran and Pillai (1976), and Mohd. Khusahry et al. (1980). It appears that greater birth weights can be achieved by crossing with Saanen (Figure 4.09)

It was observed that the birth weight of the male kids was greater than that of the female kids in all the breedgroups. Sexual dimorphism was also reported by Paramsothy (1957), Devendra (1962, 1966), Gill and Dev (1972), Rajendram and Pillai (1976), Galal et al., (1977), Lee et al., (1978) and Mohd. Khusahry et al., (1980) and Panandam (1990). However, Castillo et al., (1976), Mittal and Pandey (1978) and Mohd. Khusahry et al., (1980) found the

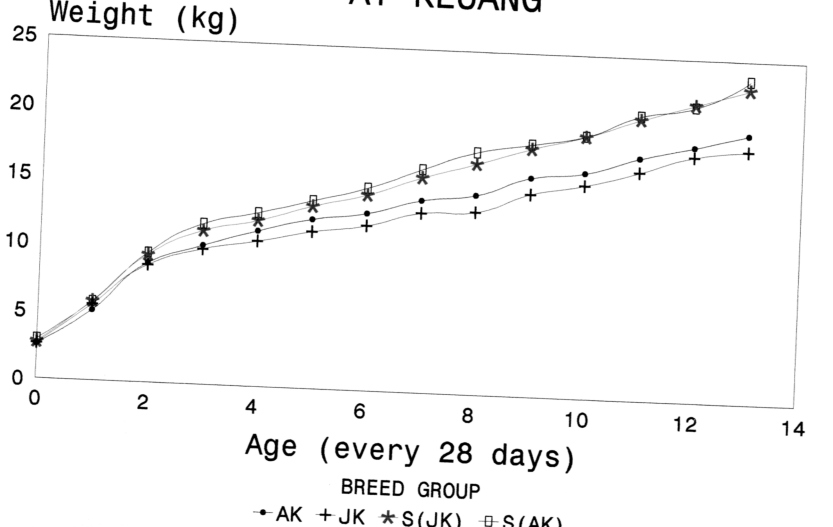
Table 4.19: Least square means of birth, weaning and year old weights of four breed groups of goat at Kluang.

Breed	Obs.	Birth wt (kg)	Weaning wt (kg)	Year old wt (kg)
AK	47	2.57±0.86 $_{b}$	11.34±0.37 $_{a}$	19.60±0.65 $_{b}$
JK	89	2.60±0.57 $_{b}$	10.60±0.28 $_{a}$	18.43±0.65 $_{b}$
S(JK)	96	2.70±0.56 $_{ab}$	12.10±0.29 $_{a}$	22.88±0.55 $_{b}$
S(AK)	41	2.90±0.97 $_{a}$	12.68±0.44 $_{a}$	23.55±0.92 $_{a}$

Means with different subscripts in column are statistically different at $P<0.05$.

Breed group: AK=Anglo Nubian x Katjang
JK=Jamnapari x Katjang
S(JK)=Saanen (Jamnapari x Katjang)
S(AK)=Saanen (Anglo Nubian x Katjang)

FIG 4.09: BODY WEIGHT INCREASE IN AK AND JK BREED GROUPS WHEN CROSSED WITH SAANEN AT KLUANG



difference due to sex to be statistically not significant ($p<0.05$). In the present study the greatest difference was in the S(AK) breedgroup (male=3.04±0.68, female=2.40±0.32). The difference between the male and female kids in S(AK) breedgroup was 0.64 kg which amounted to 23.53% of the average weight of all the kids. In the S(JK), AK and JK breedgroups the difference between the male and female kids was 0.05, 0.12 and 0.23 kg respectively. It is postulated that hormone activity was responsible for the increased growth stimulus resulting in heavier birth weight of the male.

The weight of the kids at birth is influenced by many factors such as breed, number at birth and nutritional level of dam. In the present study the difference in weight of S(AK) as compared to AK and S(JK) as compared to JK could be attributed to difference due to breed of sire. The breed of sire effect was highly significant ($P<0.01$) on birth weight (Table 4.20). It was apparent from birth to year-old. The effect of sex was more dominant in the later part of growth. The males were very much bigger than the females as observed by Aregheore (1992) in the West African Dwarf goats.

4.1.7.2 Adult weight

The weaning weight at 112 days of age was 12.68±0.44 12.10±0.29, 11.34±0.37 and 10.60±0.28 kg in the S(AK), S(JK), AK and JK breedgroups respectively. The weaning weight was statistically significant ($P<0.01$) between the breedgroups. Sex also influenced the weaning weight ($P<0.05$)

Table 4.20: ANOVA for body weight at birth, weaning and year-old of goats at Kluang.

Source	df	Birth F-value	6 months F-value	Year-old F-value
Model	15			
Year of birth-Y	3	30.13**	2.52	1.92
Season-C	3	6.52**	2.93	2.80
Birth type-K	1	21.11*	2.03	16.52**
Sex-X	1	38.66**	5.79*	18.82**
Sire breed-S	2	48.90**	13.53**	26.90**
Dam breed-D	2	10.43**	3.53*	5.14*
Progeny (P)	3	33.08**	11.89**	21.50**
Remainder	309			
Total	324			

* significant (P<0.05)
** significant (P<0.01)

whereby the males were bigger than the female kids. The interaction between breedgroup and sex was found to be not significant.

The 12 month body weight was 23.55±0.92, 22.88±0.55, 19.60±0.65 and 18.43±0.46 kg in the S(AK), S(JK), AK and JK breedgroups. Sexual dimorphism was evident and the introduction of Saanen to AK and JK breedgroups resulted in 20.15% and 24.15% improvement. Some of this performance may be attributed to hybrid vigour expressed in F1 kids of the three-breed cross. The weights recorded for the Anglo Nubian and Jamnapari inheritance in this study are similar to an earlier report (Abdul Wahid, 1981) but lower to that reported by Rajendran and Pillai (1976).

4.1.7.3 Body measurements

The mean height, length and girth of the four breedgroups at weaning and at year-old are presented in Table 4.21. At weaning the SAK had an advantage of 3.95, 6.78 and 4.06% over that of AK whereas in S(JK) the advantage was 2.31, 4.04 and 6.42% over JK. There was significant difference between S(AK) and S(JK). At year-old the difference between S(AK) and S(JK) was only significant ($P<0.05$) in wither height. The S(AK) breedgroup having higher body weight at year-old was also taller, had longer body and greater girth.

Table 4.21: Mean body measurements (height, length and girth) of four breed groups of goat at Kluang.

Age	Measurements		Breedgroup			
			AK	JK	S(JK)	S(AK)
At weaning	Ht	Mean(cm)	43.77±	44.63±	45.66±	45.50±
		S.E.(cm)	0.59	0.42	0.46	0.65
		CV (%)	8.97	8.44	9.39	8.68
	Lth	Mean(cm)	48.38±	48.99±	50.97±	51.66±
		S.E.(cm)	0.55	0.46	0.46	0.59
		CV (%)	7.78	8.83	8.90	7.26
	Gth	Mean(cm)	50.01±	48.59±	51.71±	52.04±
		S.E.(cm)	0.52	0.52	0.47	0.58
		CV (%)	7.09	9.95	8.93	7.19
At year-old	Ht	Mean(cm)	57.83±	57.66±	61.95±	61.40±
		S.E.(cm)	0.61	0.53	0.51	0.76
		CV (%)	7.12	8.32	7.96	7.71
	Lth	Mean(cm)	58.29±	57.59±	62.41±	62.05±
		S.E.(cm)	0.71	0.56	0.58	0.86
		CV (%)	8.31	8.75	8.93	8.68
	Gth	Mean(cm)	57.78±	56.80±	61.42±	61.72±
		S.E.(cm)	0.62	0.60	0.56	0.86
		CV (%)	7.31	9.51	8.70	8.65

eans with different subscripts in column are statistically

ifferent at P<0.05

reed : AK = Anglo Nubian x Katjang
JK = Jamnapari x Katjang
S(JK)= Saanen(Jamnapari x Katjang)
S(AK)= Saanen(Anglo Nubian x Katjang)

At year-old, a sample of kids were identified for carcass analysis and additional body measurements were taken as reported in Table 4.22. It was noticed that breed group S(AK) had greater birth weight and year-old body weight as well as body measurements as reported earlier in Table 4.21. The overnight fasted weight, chest width as well as chest girth were also greater as compared to that of S(JK). Of course, the AK and JK breed groups had much smaller body measurements. The year-old weight of S(AK) was 24.81% greater compared to AK and S(JK) was 19.98% greater when compared to JK. The improvement achieved with the introduction of Saanen was 6.05% in body length, 5.97% in height at withers, 6.45% in height at croup, 19.57% in width, 1.9% in depth, 4.17% in barrel girth and 8.03% in circumference of fore leg. In the S(JK) the improvement in respective body measurements were 10.01, 4.78, 3.65, 1.14, 4.19, 3.59 and 3.59%.

The birth weight was correlated with weaning weight (Table 4.23) in AK and JK; and was not significant and negative in S(AK). In fact in this breed group the birth weight was insignificantly correlated with weight, height, length, and girth at weaning. The significant correlations between the body weights and body measurements ranged between 0.26 and 0.89 in AK, 0.32 to 0.93 in JK, 0.48 to 0.93 in S(AK) and 0.42 to 0.95 in S(JK).

It was also observed that the phenotypic correlation between the live and carcass measurements (Table 4.24) were variable between the breed groups and between the

Table 4.22: Mean (±S.E) of some live measurements in a selected number of the four breed groups of goats at Kluang.

Variable	Breed group AK	JK	S(AK)	S(JK)
Observation	12	12	10	12
12 month weight (kg)	18.87±0.59^{b}	18.75±0.68^{b}	23.54±1.79^{a}	22.95±0.85^{a}
Fasted weight (kg)	17.69±0.77^{b}	17.82±0.64^{b}	22.34±1.74^{a}	21.38±0.92^{a}
Body length (cm)	59.00±0.99^{b}	58.67±1.36^{b}	62.56±2.02^{a}	64.53±1.17^{a}
Wither height (cm)	59.53±1.42^{b}	62.51±1.15^{a}	63.37±1.08^{a}	64.79±0.92^{a}
Height at croup (cm)	56.77±1.02^{b}	59.58±0.90^{b}	60.16±1.28^{a}	62.43±0.95^{a}
Chest width (cm)	13.54±0.65^{a}	14.25±0.86^{a}	16.19±1.59^{a}	14.09±0.82^{a}
Chest depth (cm)	29.38±2.97^{a}	29.37±1.83^{a}	29.94±1.51^{a}	30.60±2.63^{a}
Chest girth (cm)	58.56±0.54^{b}	61.28±1.08^{ab}	65.00±1.86^{a}	64.18±1.03^{a}
Barrel girth (cm)	67.22±0.95^{a}	67.88±0.99^{a}	70.02±4.59^{a}	70.32±0.75^{a}
Circumference of fore leg (cm)	7.10±0.10^{a}	7.24±0.12^{a}	7.67±0.30^{a}	7.50±0.16^{a}

Values with same superscripts in row are statistically not different (P>0.05)

Breed group: AK - Anglo Nubian x Katjang

JK - Jamnapari x Katjang

S(AK) - Saanen x (Anglo Nubian x Katjang)

S(JK) - Saanen x (Jamnapari x Katjang)

e 4.23: Correlation coefficient matrix of body weight and body

measurements of four breed groups of goat at Kluang.

able	Breed	Variable							
		Wt_b	Wt_w	Ht_w	Lth_w	Gth_w	Wt_y	Ht_y	Lth_y
	AK	0.39**							
	JK	0.33**							
	S(JK)	0.21*							
	S(AK)	-0.05							
	AK	0.28	0.65**						
	JK	0.34**	0.60**						
	S(JK)	0.34**	0.74**						
	S(AK)	0.09	0.76**						
	AK	0.30*	0.81**	0.79**					
	JK	0.42**	0.77**	0.78**					
	S(JK)	0.16	0.84**	0.72**					
	S(AK)	0.17	0.85**	0.71**					
	AK	0.32*	0.81**	0.48**	0.75**				
	JK	0.26*	0.85**	0.51**	0.77**				
	S(JK)	0.05	0.86**	0.53**	0.78**				
	S(AK)	-0.01	0.77**	0.42**	0.53**				
	AK	0.14	0.64**	0.23	0.53**	0.77**			
	JK	0.20	0.70**	0.32**	0.53**	0.63**			
	S(JK)	0.03	0.68**	0.48**	0.57**	0.73**			
	S(AK)	0.06	0.89**	0.63**	0.72**	0.80**			
	AK	0.21	0.65**	0.46**	0.66**	0.74**	0.80**		
	JK	0.23*	0.70**	0.50**	0.66**	0.68**	0.82**		
	S(JK)	0.10	0.69**	0.56**	0.68**	0.69**	0.87**		
	S(AK)	0.07	0.81**	0.58**	0.74**	0.71**	0.92**		
	AK	0.03	0.64**	0.34**	0.61**	0.74**	0.89**	0.87**	
	JK	0.24*	0.71**	0.43**	0.65**	0.68**	0.88**	0.90**	
	S(JK)	0.01	0.70**	0.49**	0.62**	0.77**	0.93**	0.88**	
	S(AK)	0.04	0.86**	0.67**	0.74**	0.74**	0.95**	0.94**	
	AK	0.12	0.57**	0.26*	0.49**	0.73**	0.88**	0.88**	0.87**
	JK	0.20	0.75**	0.39**	0.62**	0.68**	0.89**	0.84**	0.93**
	S(JK)	0.06	0.68**	0.49**	0.59**	0.73**	0.90**	0.90**	0.92**
	S(AK)	0.05	0.83**	0.54**	0.70**	0.78**	0.94**	0.94**	0.95**

le: Wt = Weight
Ht = Height
Lth = Length
Gth = Girth
: b = At birth
w = At weaning (112 days)
y = At 364 days of age
: AK = Anglo Nubian x Katjang
JK = Jamnapari x Katjang
S(JK) = Saanen (Jamnapari x Katjang)
S(AK) = Saanen (Anglo Nubian x Katjang)

e 4.24: Phenotypic correlation between live and carcass measurements of goats

ble	Breed group	Length of leg	Length of carcass	Width of chest	Circumference of chest	Breadth of gigot	Depth of gigot	Circumference of gigot
h body	AK	0.82**	0.78**	-0.34	0.86**	0.52	-0.08	0.65*
ht	JK	0.28	0.57	0.64*	0.89**	0.39	-0.11	0.65*
	S(AK)	0.29	0.88**	-0.07	0.95**	0.25	0.89**	0.80**
	S(JK)	0.23	0.30	0.68*	-0.05	0.46	0.40	0.66*
d weight	AK	0.77**	0.82**	-0.76**	0.76**	0.05	-0.18	0.15
	JK	0.31	0.64*	0.71**	0.87**	0.45	-0.27	0.62*
	S(AK)	0.35	0.92**	-0.08	0.96**	0.21	0.88**	0.77**
	S(JK)	0.34	0.62*	0.72**	-0.09	0.41	0.04	0.69*
length	AK	0.62*	0.77**	-0.56	0.59*	0.18	-0.13	0.24
	JK	0.31	0.42	0.48	0.70*	0.50	-0.29	0.54
	S(AK)	0.29	0.79**	-0.27	0.86**	0.31	0.91**	0.85**
	S(JK)	0.07	0.40	0.62*	-0.10	0.32	-0.03	0.55
r height	AK	0.52	0.49	-0.31	0.60*	0.05	-0.08	0.17
	JK	0.50	0.64*	0.08	0.66*	0.03	-0.01	0.16
	S(AK)	0.47	0.95**	-0.11	0.95**	0.09	0.75*	0.68*
	S(JK)	0.27	0.18	0.56	-0.27	0.53	0.16	0.65*
at	AK	0.76**	0.75**	-0.53	0.82**	0.34	-0.22	0.37
	JK	0.40	0.53	0.13	0.67*	0.20	-0.27	0.29
	S(AK)	0.45	0.85**	-0.18	0.90**	0.22	0.77**	0.80**
	S(JK)	0.13	-0.03	0.58*	-0.39	0.49	0.21	0.37
width	AK	0.32	-0.002	0.46	0.46	0.29	0.33	0.54
	JK	0.82**	0.73**	0.25	0.41	0.82**	-0.39	0.50
	S(AK)	0.54	-0.15	0.41	-0.26	-0.08	-0.49	-0.31
	S(JK)	0.75**	0.40	0.49	-0.65*	0.11	0.23	0.20
depth	AK	-0.63*	-0.36	-0.20	-0.38	-0.22	-0.48	-0.52
	JK	-0.33	0.02	-0.03	-0.02	-0.55	0.17	-0.29
	S(AK)	-0.25	0.53	0.46	0.66*	-0.13	0.70*	0.34
	S(JK)	-0.25	0.36	0.49	0.28	-0.20	-0.38	0.38
girth	AK	0.87**	0.70*	-0.32	0.73**	0.38	0.21	0.51
	JK	0.28	0.27	-0.005	0.41	0.07	-0.13	0.38
	S(AK)	0.17	0.75*	0.23	0.88**	0.26	0.81**	0.77**
	S(JK)	-0.004	0.26	0.63*	0.06	0.42	0.09	0.56
girth	AK	0.57	0.34	-0.16	0.48	0.18	0.17	0.27
	JK	0.13	0.46	0.46	0.46	0.03	-0.05	0.25
	S(AK)	-0.17	0.43	0.21	0.39	0.08	0.37	0.36
	S(JK)	0.30	0.49	0.37	0.03	0.31	0.41	0.86**
erence	AK	0.54	0.55	-0.34	0.76**	0.01	-0.27	0.14
e leg	JK	0.03	0.39	0.30	0.53	0.12	0.26	0.38
	S(AK)	0.30	0.85**	-0.02	0.95**	-0.15	0.80**	0.54
	S(JK)	0.12	0.56	0.62*	-0.05	0.26	0.22	0.88**

gnificant at P<0.05
gnificant at P<0.01

roup: AK - Anglo Nubian x Katjang
JK - Jamnapari x Katjang
S(AK) - Saanen x (Anglo Nubian x Katjang)
S(JK) - Saanen x (Jamnapari x Katjang)

variables and ranged from P<0.05 to P<0.001. Among the carcass traits the highly significant (P<0.01) effect was observed in the relationships between the year-old weight, fasted weight, body length, wither height and height at croup with length of carcass, circumference of chest and circumference of gigot in S(AK) and AK breed groups. The advantage of Saanen in the S(AK) breed group was evident as depicted by the relationship between the variables.

4.1.7.4 Average Daily Gain

The pre-weaning average daily gain (ADG) was better in S(AK) breedgroup than in S(JK) breedgroup (87.13 vs. 83.98 gm/day) (Table 4.25). The S(AK) breedgroup had an advantage of 11.28% over AK breedgroup and S(JK) had an advantage of 17.65% over JK breedgroup. The superiority of the S(AK) and S(JK) over the AK and JK breedgroups respectively was also evident in the post-weaning ADG where S(AK) was 33.56% better than AK, and S(JK) was 42.37% better than JK breedgroups. Galal and Kebede (1977) working with Saanen x Adel crossbreds in Ethiopia recorded pre-weaning and post-weaning ADG of 85 and 80 gm/day. The superiority of crossbred kids of Saanen inheritance in this study confirms an earlier report of Mohd. Khusahry et al., (1980), where it was shown that crossbred kids of Saanen inheritance grew faster and were heavier at 90 days of age when compared to crossbred kids of British Alpine. There was no significant difference between S(AK) and (JK) breed groups in pre-weaning, post-weaning as well as overall ADG.

Table 4.25: Pre-weaning and Post-weaning Average Daily Gain (gm/day) of four breed groups of goat at Kluang.

Breed	Pre-weaning (0-112 days)	Post-weaning (113-364 days)	Overall (0-364 days)
AK	78.31 ± 3.10^{ab}	32.78 ± 1.98^{b}	46.83 ± 1.77^{b}
JK	71.38 ± 2.40^{b}	30.02 ± 1.30^{b}	43.31 ± 1.24^{b}
S(JK)	83.98 ± 2.59^{a}	42.74 ± 1.63^{a}	55.39 ± 1.52^{a}
S(AK)	87.13 ± 4.09^{a}	43.86 ± 2.07^{a}	56.67 ± 2.52^{a}
Overall	79.40 ± 1.49	37.20 ± 0.93	50.38 ± 0.90

Means with different superscripts in column are statistically different at $P<0.01$.

Breeds AK = Anglo Nubian x Katjang
JK = Jamnapari x Katjang
S(JK)= Saanen x (Jamnapari x Katjang)
S(AK)= Saanen x (Anglo Nubian x Katjang)

inheritance in this study confirms an earlier finding (Mohd. Khusahry et al. 1980), where it was shown that crossbred kids of Saanen inheritance grew faster and were heavier at 90 days of age when compared to crossbred kids of British Alpine.

4.1.7.5 Growth curves

The performance of the Levenburg-Marquardt algorithm for estimating the parameters on data of body weight, height, length and girth of the goats are depicted in Table 4.26. The rate of convergence criterion was met in 22 25, 28 and 20 iterations. The convergent algorithm indicated that the minimal residual sum of squares are in agreement with the regression sum of squares. The convergence implied that the best estimates of the non-linear parameters had been procured under the assumption that the fitted model was adequate.

The t-test on the parameters (A, B, Y) depicted that the parameters were well determined. The estimated parameters contributed significantly ($P<0.05$) to the fitted Gompertz model. The sign of the confidence intervals which were all positive indicated that the estimated parameters were conditionally well determined. The values of coefficient of determination (R^2) were highly significant ($P<0.01$). The assessment, thus, presented the aptness of the Gopertz model for body weight and body measurements. The plotting of observed and predicted body weight and body measurements using the above model were close to each other.

The simple linear, quadratic, exponential and logarithmic models (Tables 4.27) were very highly significant ($P<0.001$) indicating the accuracy of the models to illustrate growth of body weight and body measurements of AK, JK, S(AK) and S(JK) breed groups of goats.

Table 4.26: The adequate prediction models for growth parameters against age.

Breed group	Parameter	Equation Y = a + bW	R^2
AK	Weight	Wt = 5.00 + 1.58W - 0.04W² (0.67) (0.22) (0.02)	97.7**
	Height	Ht = 36.47 + 1.60W (1.25) (0.16)	90.4**
	Length	Lth = 45.18 + 0.95W (0.56) (0.07)	94.4**
	Girth	Gth = 46.12 + 1.62W - 0.05W² (1.07) (0.35) (0.02)	92.1**
JK	Weight	Wt = 6.22 + 0.96W (0.37) (0.05)	97.4**
	Height	Ht = 37.59 + 1.44W (1.17) (0.15)	89.7**
	Length	Lth = 45.28 + 0.88W (0.61) (0.08)	92.5**
	Girth	Gth = 47.67 + 0.84W (0.91) (0.11)	83.1**
S(JK)	Weight	Wt = 6.42 + 1.29W (0.14) (0.05)	98.3**
	Height	Ht = 37.24 + 1.82W (1.34) (0.17)	91.4**
	Length	Lth = 46.57 + 1.15W (0.75) (0.09)	93.1**
	Girth	Gth = 47.20 + 2.08W- 0.08W² (1.39) (0.46) (0.03)	91.1**
S(AK)	Weight	Wt = 5.38 + 1.85W- 0.04W² (0.75) (0.24) (0.02)	98.2**
	Height	Ht = 36.34 + 1.91W (1.46) (0.18)	90.7**
	Length	Lth = 50.25 + 0.95W (0.81) (0.10)	88.8**
	Girth	Gth = 3.87 + 0.02W (0.01) (0.02)	93.1**

** Significant at P<0.01

Breeds: AK = (Anglo Nubian x Jamnapari)
JK = (Jamnapari x Katjang)
S(JK) = Saanen x (Jamnapari x Katjang)
S(AK) = Saanen x (Anglo Nubian x Katjang)

W - Age
( ) - Standard Error

4.27: Regression statistics of body weight and body measurements on age in goats

Variable	Model	Parameters	Estimate	S.E	T	Prob>|t|	R^2
Wt	Simple Linear	a	6.3225	0.4868	12.99	0.0001	96.4
		b	1.0475	0.0613	17.08	0.0001	
	Quadratic	a	4.9989	0.6689	7.48	0.0001	97.8
		b	1.5769	0.2197	7.18	0.0001	
		c	-0.0378	0.0153	-2.48	0.0327	
	Exponential	a	19.0372	1.1534	16.51	0.0001	
		b	0.2235	0.0355	6.30	0.0001	
Ht	Simple Linear	a	36.4670	1.2492	29.19	0.0001	90.4
		b	1.5998	0.1574	10.17	0.0001	
	Quadratic	a	34.6021	2.0509	16.87	0.0001	91.5
		b	2.3457	0.6738	3.48	0.0059	
		c	-0.0533	0.0468	-1.14	0.2817	
	Exponential	a	50.1550	1.8249	27.48	0.0001	
		b	0.2314	0.0435	5.32	0.0001	
Lth	Simple Linear	a	45.1807	0.5564	81.20	0.0001	94.4
		b	0.9514	0.0701	13.57	0.0001	
	Quadratic	a	45.0516	0.9695	46.47	0.0001	94.4
		b	1.0031	0.3185	3.15	0.0103	
		c	-0.0037	0.0221	-0.17	0.8710	
	Exponential	a	52.4776	1.0503	49.96	0.0001	
		b	1.9820	0.4982	3.98	0.0001	
Gth	Simple Linear	a	48.0393	0.7499	64.06	0.0001	88.1
		b	0.8517	0.0945	9.01	0.0001	
	Quadratic	a	46.1230	1.0665	43.25	0.0001	92.1
		b	1.6182	0.3504	4.62	0.0001	
		c	-0.0548	0.0244	-2.25	0.0483	
	Exponential	a	54.6249	0.9536	57.28	0.0001	
		b	2.0348	0.4602	4.42	0.0001	
Wt	Simple Linear	a	6.2214	0.3726	16.70	0.0001	97.4
		b	0.9554	0.0469	20.35	0.0001	
	Quadratic	a	5.6246	0.6046	9.29	0.0001	97.8
		b	1.1941	0.1990	6.00	0.0001	
		c	-0.0171	0.0138	-1.23	0.2458	
	Exponential	a	17.7115	1.2428	14.26	0.0001	
		b	0.2314	0.0435	5.32	0.0001	
Ht	Simple Linear	a	37.5874	1.1698	32.13	0.0001	89.7
		b	1.4449	0.1474	9.80	0.0001	
	Quadratic	a	37.0292	2.0291	18.25	0.0001	89.9
		b	1.6686	0.6666	2.50	0.0313	
		c	-0.0160	0.0463	-0.35	0.7374	
	Exponential	a	49.2860	1.6726	29.47	0.0001	
		b	1.1847	0.3202	3.70	0.0001	

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Lth	Simple Linear	a	45.2752	0.6050	74.84	0.0001	92.5
		b	0.8844	0.0762	11.60	0.0001	
	Quadratic	a	45.5463	1.0501	43.37	0.0001	92.5
		b	0.7759	0.3450	2.25	0.0482	
		c	0.0077	0.0240	0.32	0.7532	
	Exponential	a	51.9685	1.0124	51.33	0.0001	
		b	2.1829	0.6018	3.63	0.0001	
Gth	Simple Linear	a	47.6681	0.9092	52.80	0.0001	83.1
		b	0.8368	0.1138	7.36	0.0001	
	Quadratic	a	45.4347	1.3041	34.84	0.0001	88.4
		b	1.7302	0.4284	4.04	0.0001	
		c	-0.6380	0.0298	-2.14	0.0577	
	Exponential	a	54.2489	0.9154	59.26	0.0001	
		b	1.9039	0.3856	4.94	0.0001	
Wt	Simple Linear	a	6.4201	0.4119	15.59	0.0001	98.3
		b	1.2896	0.0519	24.85	0.0001	
	Quadratic	a	5.3873	0.5912	9.11	0.0001	98.8
		b	1.7027	0.1942	8.77	0.0001	
		c	-0.0295	0.0135	-2.19	0.0537	
	Exponential	a	23.4790	1.7830	13.17	0.0001	
		b	0.1810	0.0312	5.80	0.0001	
Ht	Simple Linear	a	37.2366	1.3352	27.89	0.0001	91.4
		b	1.8174	0.1682	10.80	0.0001	
	Quadratic	a	36.6056	2.3162	15.80	0.0001	91.5
		b	2.0698	0.7609	2.72	0.0216	
		c	-0.0180	0.0529	-0.34	0.7403	
	Exponential	a	52.7941	2.1383	24.69	0.0001	
		b	0.8422	0.2172	3.88	0.0001	
Lth	Simple Linear	a	46.5679	0.7481	62.25	0.0001	93.1
		b	1.1491	0.0942	12.19	0.0001	
	Quadratic	a	46.7076	1.3041	35.82	0.0001	93.1
		b	1.0932	0.4284	2.55	0.0288	
		c	0.0040	0.0298	0.13	0.8961	
	Exponential	a	55.3493	1.3095	42.27	0.0001	
		b	1.8982	0.5372	3.53	0.0001	
Gth	Simple Linear	a	49.8953	0.9937	50.21	0.0001	86.1
		b	1.0318	0.1252	8.24	0.0001	
	Quadratic	a	47.2045	1.3866	34.09	0.0001	91.1
		b	2.0842	0.4555	4.58	0.0001	
		c	-0.0752	0.0317	-2.37	0.0390	
	Exponential	a	58.0078	1.1358	51.07	0.0001	
		b	1.7809	0.3900	4.57	0.0001	
Wt	Simple Linear	a	6.7674	0.5258	12.87	0.0001	97.2
		b	1.2908	0.0662	19.49	0.0001	
	Quadratic	a	5.3765	0.7340	7.33	0.0001	98.2
		b	1.8472	0.2411	7.66	0.0001	
		c	-0.0397	0.0168	-2.37	0.0392	
	Exponential	a	23.2915	1.6010	14.55	0.0001	
		b	0.1948	0.0319	6.11	0.0001	

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Ht	Simple Linear	a	36.3388	1.4632	24.83	0.0001	90.7
		b	1.9125	0.1844	10.37	0.0001	
	Quadratic	a	34.3720	2.4316	14.14	0.0001	91.6
		b	2.6992	0.7988	3.38	0.0070	
		c	-0.0562	0.0555	-1.01	0.3354	
	Exponential	a	53.5217	2.2111	24.21	0.0001	
		b	0.6909	0.1607	4.30	0.0001	
Lth	Simple Linear	a	47.5026	0.6708	70.82	0.0001	93.1
		b	1.0252	0.0845	12.13	0.0001	
	Quadratic	a	47.3507	1.1688	40.51	0.0001	93.1
		b	1.0860	0.3840	2.83	0.0179	
		c	-0.0043	0.0267	-0.16	0.8741	
	Exponential	a	55.3767	1.1440	48.41	0.0001	
		b	1.9485	0.4958	3.93	0.0001	
Gth	Simple Linear	a	50.2504	0.8099	62.05	0.0001	88.8
		b	0.9523	0.1020	9.33	0.0001	
	Quadratic	a	48.3507	1.1966	40.41	0.0001	92.0
		b	1.7122	0.3931	4.36	0.0014	
		c	-0.0543	0.0273	-1.99	0.0751	
	Exponential	a	57.6977	1.0282	56.12	0.0001	
		b	1.8881	0.4001	4.72	0.0001	

Y = a + bX

tic Y = a + bX + cX²

ntial Y = a(1-e $^{-bX}$)

where Y = Response variate (body wt or body measurement)

X = Age (in week)

a = intercept

b = slope

c = curvature.

4.2 Growth performance of goats at Serdang

4.2.1 Birth weight

As in Kluang, a study also was conducted at Serdang using a small sample of does of KK, AK and SK breed groups. The purebred Katjang (KK) parent stock which were available at MARDI at the time of the study were original and authentic stock of Katjang goats which had uniform black coat colour and possessed all the known characteristics of the Katjang breed. They had been born on the farm and their birth weight and pedigree was known. This stock was the result of the recommendations of the Livestock Technical Committee in the form of the National Breeding Policy which suggested that the KK be used as the female base population for crossbreeding and thus justified the emphasis on the KK for purebreeding to produce replacement stock. The Anglo Nubian and Saanen were pedigreed stock imported from Australia and deemed to be pure

The data collected at Serdang when analysed showed that the mean birth weight of purebred Katjang (KK) in Table 4.28 was quite low (1.39$\pm$0.32 kg) as compared to the birth weight of crossbreds of Anglo Nubian x Katjang (AK) which recorded 1.75$\pm$0.51 kg and crossbred of Saanen x Katjang (SK) which recorded 1.84$\pm$0.56 kg. There was not much difference between the birth weight of the AK and SK crossbreds. The birth weight of these two breedgroups was comparable with performance of some tropical breeds in the hot and humid areas such as the Philippines, West Indies, Indonesia and West Africa.

Table 4.28: Mean birth weight, Weaning weight and 364-day body weight of purebred and crossbred Katjang goats at Serdang

Breed	N		Birth wt (kg)	Weaning wt (kg)	364-day wt (kg)
KK	34	Mean	1.39 b	7.02 b	10.52 b
		SE	0.32	0.28	0.37
		CV %	23.28	36.55	41.39
AK	29	Mean	1.75 a	9.31 a	13.65 a
		SE	0.51	0.57	0.57
		CV %	29.31	35.60	37.52
SK	32	Mean	1.97 a	9.11 a	13.32 a
		SE	0.56	0.86	0.57
		CV %	30.55	44.05	49.54

Means with same subscripts in column are statistically not significant (P>0.05).

Breeds: KK = Katjang purebred
AK = Anglo Nubian x Katjang crossbred
SK = Saanen x Katjang crossbred

SE = Standard Error
CV = Coefficient of variation

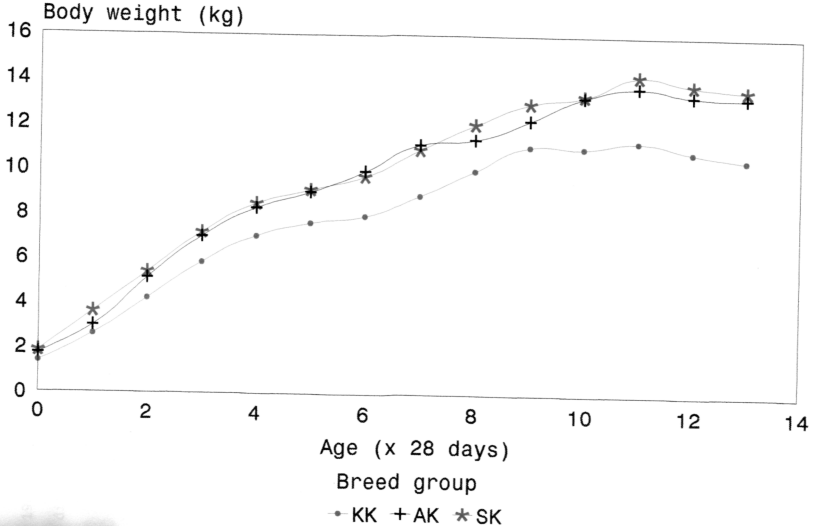
4.2.2 Adult weight

The trend was similar in the weaning weight as well as year-old weight where the Katjang purebred had the lowest body weight as compared to the crossbreds with Anglo Nubian and with Saanen. The low birth weight of Katjang has been reported by a number of other workers (Paramsothy, 1957; Mahmud and Devendra, 1970; Banumathi, 1982).

The year-old weight was 10.52 kg in the KK purebred (Fig. 4.10) which was lower than SK by 26.62% and lower than AK by 29.75%. The CV of the body weights suggests that there is significant variability in the genetic pool of the breed groups whereby the maximum weight achieved by the above breed groups was very variable. This difference could only be reduced by doing intensive selection within the breed groups based on the desirable characteristics. However, negative response could also be achieved if the selection procedure is not adhered to as happened in Jamnapari x Katjang crossbreds at Kluang.

Live weight before weaning largely depends on the age, weight and genotype of the dam and mothering ability of the does. Growth will not be affected if there is enough milk for the kid or kids. The lack of milk and competition between the litter mates for the limited volume of milk could affect the growth performance and if not supplemented could cause the animal to be stunted or might even cause mortality in the kids. The different authors (Castillo et al., 1972; Ali et al., 1973; Quartermain, 1973; Mittal and Pandey, 1978; Rana,

FIG 4.10: MEAN MONTHLY BODY WEIGHT OF KK, AK AND SK BREED GROUPS OF GOAT AT SERDANG



1980, etc.) have given different weaning weights for different breed groups at different ages.

Weaning weight of different breed groups has been so variable as reported by different authors in different countries. It is, therefore, not justified to make a generalized statement on the performance of the goats at "weaning" unless the age of the progeny at "weaning" or at the time of study is specified. Most often the kids are weaned either at three months or four months of age.

The birth, weaning and year old weights of the purebreds and crossbreds in this study were a little low but comparable to the smaller breeds of the humid tropics such as Maltese (Montemurro, 1966), Black Bengal (Moulick and Syrstal, 1970; Ali et al., 1973), Criollo (Castillo et al., 1972), Barbari (Mittal and Pandey, 1978), West African Dwarf and Mauritius (Fielding, 1980), Malabari (Mukundan et al., 1981) and Criollo (Alam, 1992).

Weaning weight also varies according to the purpose of kid rearing. Genotype of progeny, season of kidding and litter size (Rana, 1980) also influences weaning. The weaning weight in the Katjang was lower as compared to some of the foreign breed groups such as Anglo Nubian, Jamnapari, Alpine, Maltese, etc. (Montemurro, 1966; Ali et al., 1973; Rajendram and Pillay, 1976; and Mittal and Pandey, 1978).

The analysis of variance did not suggest any influence of year of birth and sex on birth, weaning and year-old weights (Table 4.29). The effect of breed group was

Table 4.29: ANOVA to show effect of year of birth, breed group and sex on birth, weaning and year old body weights of purebred and crossbred Katjang goats at Serdang.

Source	df	Bth wt F-value	Weaning wt F-value	Adj 180-day wt F-value	Adj 360-day wt F-value	Year-old wt F-value
Model	13	1.70	1.54	2.80	2.15	2.68
Year of birth (YB)	2	2.41	1.23	11.44**	7.61**	0.69
Breed group (BG)	2	3.60*	1.39	1.12	1.08	4.09*
Sex (S)	1	0.11	0.01	0.06	0.04	2.18
YB x BG	4	0.25	0.17	0.19	0.24	1.21
BG x S	2	0.14	1.00	0.88	0.28	0.61
YB x S	2	0.06	0.80	0.75	1.62	0.85
Error	82					
Total	95					

* Significant at P<0.05
* Significant at P<0.01

highly significant ($P<0.05$) on birth weight, weaning weight and year-old weight. However, year of birth was not significant on weaning weight as well as year-old weight. Surprisingly sex had no effect on birth, weaning and year-old weights. The two-factor effects were also not significant on the three variables such as birth, weaning and year-old weights.

4.2.3 Body measurements

The usual criteria employed to study changes in growth and development have been body weight and linear measurements. Since growth is a relatively continuous process it is better characterized by rate of gain per unit time than by actual weight.

Comparing the purebred with the crossbred it was found that the crossbreds had a bigger frame as demonstrated by the variation of the body measurements such as wither height, body length and chest girth (Table 4.30). The superiority of the Saanen crossed with Katjang was illustrated at weaning, but as the animals grew older the cross of Anglo Nubian with Katjang over-shadowed the other two breed groups. However, there was no significant difference between the body measurements of AK and SK except in the wither height.

The relationship between birth weight and subsequent body weights as well as with body measurements was investigated. The body measurements were strongly

Table 4.30: Means ± S.E. of body measurements at weaning and year-old in purebred and crossbred Katjang goats at Serdang.

Breed group	At Weaning			At Year-old		
	Ht (cm)	Lth (cm)	Gth (cm)	Ht (cm)	Lth (cm)	Gth (cm)
KK	39.09± 0.66 a	41.00± 0.96 a	43.82± 0.90 b	44.91± 0.79 b	49.06± 1.08 a	53.28± 0.95 b
SK	40.24± 0.85 a	43.13± 0.76 a	46.52± 0.89 a	49.05± 1.07 a	53.00± 1.28 a	57.31± 1.11 a
AK	41.35± 0.86 a	44.65± 0.82 a	47.19± 0.87 a	45.42± 0.72 b	53.68± 0.88 a	58.36± 1.03 a

a, b Means with same subscripts in column are statistically not significant ($P<0.05$).

Breed group: KK = Katjang purebred
AK = Anglo Nubian x Katjang crossbred
SK = Saanen x Katjang crossbred

Ht = Wither height
Lth = Body length
Gth = Chest girth

correlated with body weights at birth, weaning and at year-old in AK breed group but not in KK (Table 4.31). In SK the body weight at weaning and year-old was also highly correlated ($P<0.01$) with body measurements. The correlation between weights and body measurements in KK was not significant and in some cases it was negative.

The multiple regression of yearling weight on height, length and girth in the three breed groups are given in Table 4.32. All the three equations for KK, AK and SK were found to be statistically significant. The coefficient of determination (R^2) was statistically significant ($P<0.05$) in KK and highly significant ($P<0.01$) in AK and JK breed groups. The values ranged from 0.52 in KK to 0.86 in AK and 0.85 in SK. These values are within the range reported by Eikje (1974), Olson et al., (1976), Martin et al., (1980), and Alrawi et al., (1982) which is 0.68 to 1.00. The year-old weight of the three breed groups could be estimated using the above equations.

4.2.4 Average Daily Gain (ADG).

The growth rate is defined as the average gain of animal per unit time. The rate of growth represents the genetic potential of the animal for growth and mothering ability. Residual variation is largely attributable to environmental variation. The pre-weaning growth is a function of maternal performance exerted through rearing, suckling and weaning methods (Mavroginis et al., 1980). The post weaning

Table 4.31: Simple correlation coefficients of some variables in purebred and crossbred goats at Serdang.

		Weaning				Year-old			
		Wt	Ht	Lth	Gth	Wt	Ht	Lth	Gth
Bth wt	KK	0.22	0.04	0.04	0.31	-0.07	-0.20	0.12	0.17
	AK	0.73**	0.60**	0.70**	0.68**	0.68**	0.66**	0.68**	0.72**
	SK	0.35	0.25	0.41*	0.36	0.33	0.35	0.38	0.59**
Weaning wt	KK		0.23	0.92**	0.94**	0.51*	0.45	0.65**	0.68**
	AK		0.87**	0.90**	0.94**	0.87**	0.85**	0.87**	0.86**
	SK		0.85**	0.91**	0.79**	0.89**	0.79**	0.79**	0.78**
Year-old wt	KK		0.18	0.58*	0.25		0.36	0.34	0.70**
	AK		0.79**	0.79**	0.88**		0.80**	0.90**	0.89**
	SK		0.76**	0.68**	0.86**		0.91**	0.80**	0.85**

* Significant at P<0.05
** Significant at P<0.01

Wt = Weight
Ht = Height
Lth = Length
Gth = Girth

Breed group: KK = Katjang x Katjang purebred
AK = Anglo Nubian x Katjang crossbred
SK = Saanen x Katjang crossbred

Table 4.32: Multiple regression of yearling weight on height, length and girth of purebred and crossbred Katjang goats at Serdang.

Breed	Regression equation	R^2
KK	Yearling wt = -08.22-0.04Ht-0.10Lth+0.48Gth	0.52*
AK	Yearling wt = -18.92+0.02Ht+0.30Lth+0.27Gth	0.86**
SK	Yearling wt = -25.63+0.51Ht+0.10Lth+0.15Gth	0.85**

* Significant at P<0.05
** Significant at P<0.01

Ht = Height
Lth = Length
Gth = Girth

growth is important and determines the meat producability upto market age.

In the present study the pre-weaning and post-weaning ADG (Average Daily Gain) in KK was the lowest as compared to the other breed groups (Table 4.33) which resulted in lower body weights at weaning and year-old. There was no significant difference (P>0.05) between the AK and SK breed groups though the SK had a slight advantage over the AK. The overall growth rate could be improved by improving the nutrition of the animals.

Sex effect was evident on growth rate of kids. Post-weaning growth rate was 81.08 and 51.70 gm/day in females and males respectively. Comparatively the gain per day of Beetal females and Black Bengal females was 32-117% of that of males. Prolificacy of a breed also infuences the growth rate.

.2.5 Growth rate

Since growth is a relatively continuous process it s better characterized by rate of gain per unit time than by ctual weight. The asymptotic growth curve or the exponential ecay growth curve (Von Bertalanffy, 1960) is quite often sed to describe growth which is greatest initially and ecreases exponentially.

It was observed that the growth rate decreased with ime and was positive until about the 324th day when it ecame negative (Table 4.34). This negative trend was present n all the three breed groups (Figures 4.11, 4.12 and 4.13).

Table 4.33: Mean Average Daily Gain (ADG) of purebred and crossbred Katjang goats at Serdang.

Breed group	Pre-weaning (0-112 days)	Post-weaning (113-364 days)
KK	69.55± 3.29 ^{b}	20.60± 1.29 ^{b}
AK	85.27± 5.07 ^{a}	30.16± 1.13 ^{a}
SK	81.61± 5.64 ^{a}	32.86± 1.21 ^{a}

a, b Means with same subscripts in column are statistically not significant ($P<0.05$).

Breed group: KK = Katjang purebred
AK = Anglo Nubian x Katjang crossbred
SK = Saanen x Katjang crossbred

Table 4.34: Instantaneous Relative Growth Rate, Average Relative Growth Rate and Average Absolute Growth Rate of purebred and crossbred Katjang goats at Serdang.

	KK			AK			SK		
Age days	IRGR %	ARGR %	AAGR kg	IRGR %	ARGR %	AAGR kg	IRGR %	ARGR %	AAGR kg
0	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
28	62.81	86.53	01.22	53.41	70.60	01.24	67.17	95.77	01.77
56	48.80	61.28	01.60	53.72	71.12	02.13	39.80	48.88	01.77
84	32.71	38.69	01.63	39.10	36.47	01.87	28.82	33.40	01.80
112	18.39	20.19	01.18	17.01	13.56	01.30	16.61	18.07	01.30
140	08.21	03.56	00.60	08.35	08.70	00.72	07.23	07.49	00.63
168	04.03	04.11	00.31	09.88	10.38	00.93	06.46	06.68	00.61
196	10.80	11.41	00.91	11.25	11.91	01.18	11.47	12.16	01.18
224	12.13	12.90	01.14	02.18	02.21	00.25	09.95	10.43	01.14
252	10.37	10.90	01.09	07.40	07.68	00.87	07.61	07.91	00.95
280	-02.41	-02.39	-00.26	08.15	08.50	01.04	02.64	02.68	00.35
308	04.52	04.63	00.50	03.38	03.44	00.46	06.56	06.78	00.90
336	-04.06	-03.98	-00.45	-02.63	-02.60	-00.36	-02.72	-02.68	-00.38
364	-03.16	-03.11	-00.34	-00.43	-00.43	-00.06	-01.49	-01.48	-0.20

Breed group: KK=Katjang purebred
AK=Anglo Nubian x Katjang crossbred
SK=Saanen x Katjang crossbred

IRGR=Instantaneous Relative Growth Rate $= \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \times 100$ %

AAGR=Average Absolute Growth Rate $= \frac{W_2 - W_1}{t_2 - t_1}$ gm

ARGR=Average Relative Growth Rate $= \frac{W_2 - W_1}{1/2(t_2 + t_1)} \times 100$ %

FIG 4.11: AVERAGE ABSOLUTE GROWTH RATE IN PUREBRED AND CROSSBRED GOATS AT SERDANG

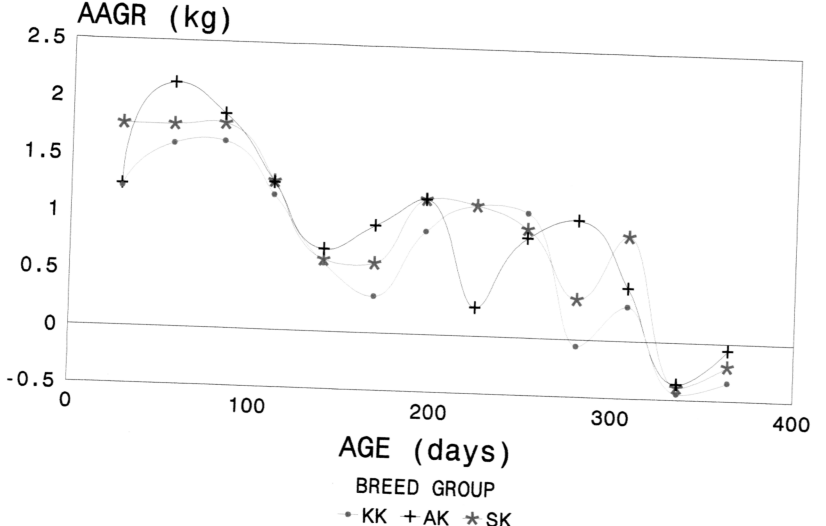


FIG 4.12: INSTANTANEOUS RELATIVE GROWTH RATE IN PUREBRE AND CROSSBRED GOATS AT SERDANG

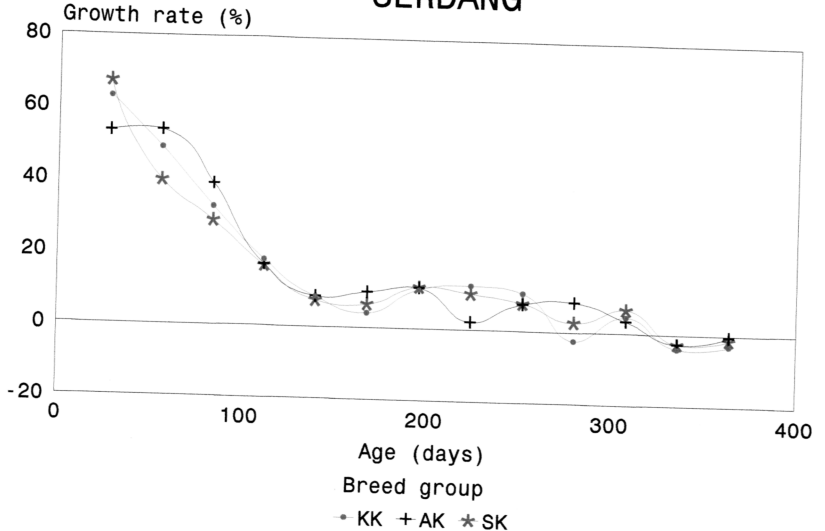
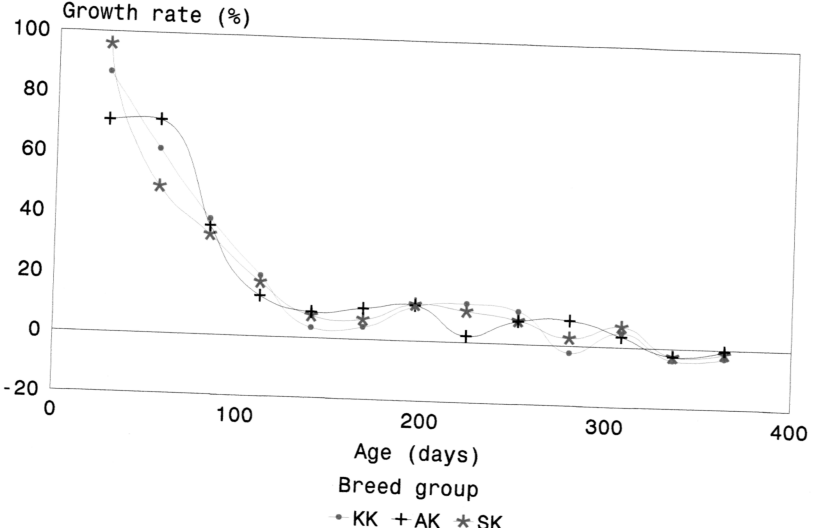


FIG 4.13: AVERAGE RELATIVE GROWTH RATE IN PUREBRED AND CROSSBRED GOATS AT SERDANG



The chi-square test of paired data indicated highly significant difference (X^2 = 31.02; P<0.01) between observed and estimated growth rates in Saanen x Katjang crossbred progeny and very highly significant difference between the observed and estimated growth rates of Katjang x Katjang (X^2 = 62.74; P<0.001) and Anglo Nubian x Katjang progeny (X^2 = 47.55; P<0.001).

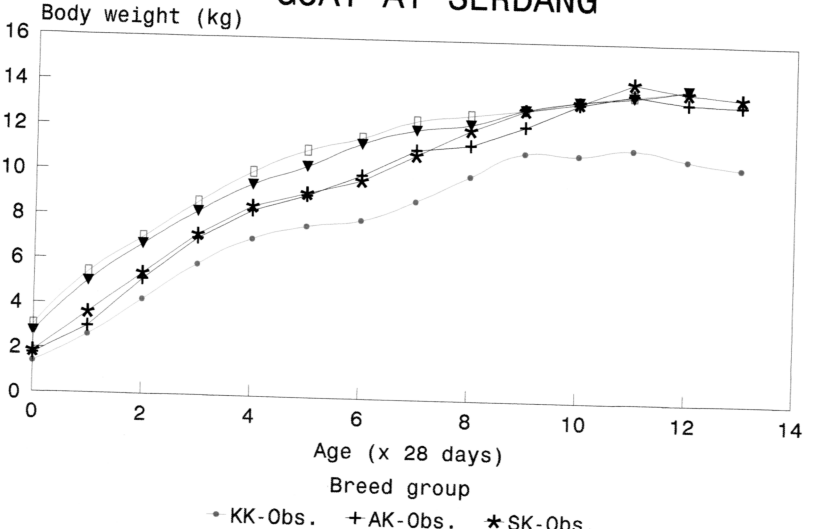
4.2.6 Growth curve

Data on body weight of three breed groups of goat were collected utilizing randomized complete block design from MARDI Serdang. The plot of the growth data (weight) on time-period (age) indicated that the scattered points were S-shaped in nature. An intrinsically non-linear sigmoid Gompertz curve was fitted on to the growth (body weight) using SAS package, PROC NLIN performed on mainframe computer. Ad hock starting values had excellently aided the non-linear least squares Lavenberg-Marquardt iterative algorithm to arrive at stationary points very rapidly in 26 iterations for purebred Katjang, 25 iterations for crossbred Saanen x Katjang and 26 iterations for crossbred of Anglo Nubian x Katjang.

The statistical diagnostics tests constituting t-ratio, confidence interval, parameter correlation matrix were performed on the parameters of the Gompertz curve. The tests exhibited that the parameters were significant (P<0.05). On examination of the residual analysis and normality test of the model it was imperatively determined that the three

parameters Gompertz curve is the most apt function to describe the growth of the goats at Serdang (Figure 4.14). The relative growth rates of the three breed groups of goat was $Wt=11.9691(1-e^{-0.2232t})$ in breed D, $Wt=14.7899(1-e^{-0.2207t})$ in breed K and $Wt=14.9600(1-e^{0.20t})$ in breed N.

FIG 4.14: GOMPERTZ GROWTH CURVE FOR BODY WEIGHT OF KK, AK AND SK BREED GROUPS OF GOAT AT SERDANG



4.2.7 Comparative growth performance in some selected breed groups of goat as observed in a trial at Serdang.

4.2.7.1 Body weight

As in Kluang, a study also was conducted at Serdang using a small sample of does of AK and SK breed groups. The parent stock which were available at MARDI at the time of the study were original and authentic stock of Katjang goats which had uniform black coat colour and all the known characteristics of the Katjang breed. They had been born on the farm and their birth weight and pedigree was known. This was the result of the recommendations of the Livestock Technical Committee in the form of the National Breeding Policy which suggested that the KK be used as the female base population for crossbreeding and thus justified the emphasis on the KK for purebreeding to produce replacement stock. The Anglo Nubian and Saanen were pedigreed stock imported from Australia and were deemed to be pure stock.

Mean birth, weaning and 12 month body weights of the different breedgroups of goat are presented in Table .35 and graphically presented in Figure 4.15. The Katjang (KK) progeny recorded the lowest birth, weaning and 12 month weights. The birth weight of KK goats resembled that of Black Bengal of India (Guha et al., 1968) and West African Dwarf goat of Ghana and Nigeria (Sada and Vohradsky, 1973). Devendra and Nozawa (1975) had also reported similar birth weight for the Katjang breed. Rajendram and Pillay (1976),

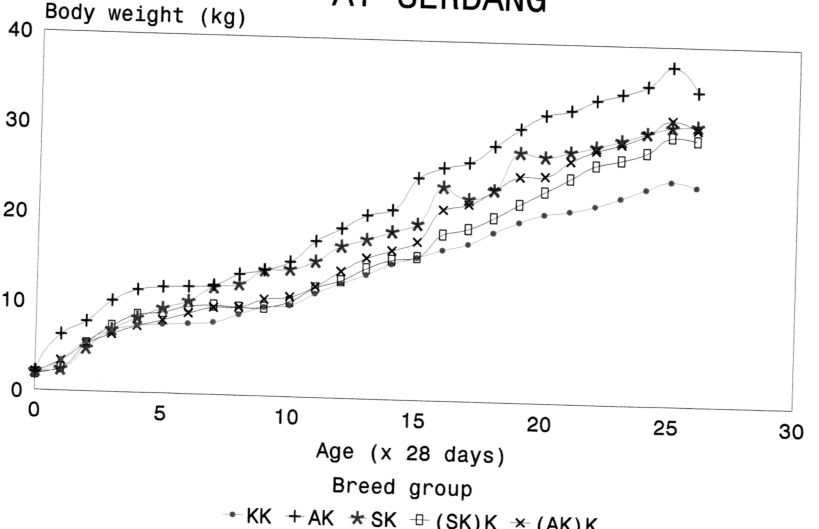
Table 4.35: Least square means (±S.E) for birth, weaning, year-old and two-year old body weights of purebred and crossbred goats at Serdang.

Breed group	Birth wt (kg)	Weaning wt (kg)	Year-old wt (kg)	Two-year wt (kg)
KK	1.57 ± 0.05^{c}	6.53 ± 0.26^{d}	13.86 ± 0.75^{d}	24.42 ± 0.86^{c}
SK	2.14 ± 0.05^{b}	8.56 ± 0.29^{bc}	16.13 ± 0.83^{c}	31.18 ± 2.01^{ab}
AK	2.06 ± 0.05^{b}	8.31 ± 0.28^{bc}	16.98 ± 0.73^{c}	34.97 ± 1.24^{a}
(SK)K	1.91 ± 0.10^{d}	7.38 ± 0.48^{dc}	18.31 ± 1.52^{cb}	29.60 ± 1.42^{bc}
(AK)K	2.10 ± 0.10^{b}	7.84 ± 0.46^{c}	17.04 ± 1.37^{c}	30.78 ± 2.17^{ab}

Values with same superscripts in column are statistically not different (P>0.05)

Breeds : KK = Katjang purebred
AK = Anglo Nubian X Katjang crossbred
SK = Saanen X Katjang crossbred
(AK)x K = (Anglo Nubian x Katjang) x Katjang cross
(SK)x K = (Saanen x Katjang) x Katjang cross

FIG 4.15: MEAN BODY WEIGHT INCREMENT IN DIFFERENT BREED GROUPS OF GOAT IN A TRIAL AT SERDANG



however, recorded the birth weight of the local Katjang to be 1.8 kg in female and 1.4 kg in male.

In the present study there was no difference between birth weight of singles and twins in agreement with Mohammed and Amin (1996). However, the twelve month body weights recorded in this study were similar to those recorded for the Kottukachiya (Buvanendran et al., 1974), Black Bengal (Singh et al., 1979) and Grey Bengal goats (Mukherjee, 1978). Sexual dimorphism was more evident in the Katjang than in Katjang crossbred goats. Body weight was highly significant between breed groups at all ages but the difference between sexes was significant ($P<0.05$) at 12 months and not at 6 and 9 months of age. Abdul Wahid and Mukherjee (1981) have earlier reported the males to be heavier than the females at various ages.

The year-old body weight of Katjang (KK) was low as compared to some earlier reports (Devendra, 1962, 1966; Mahmud and Devendra, 1970; Abdul Wahid and Mukherjee, 1985). It should be noted that some results reported by some authors may not necessarily be that of pure Katjang goats but more likely to be that of graded Katjang goat on higher plane of nutrition.

The two year-old weight of purebred Katjang was quite significant (24.42 kg), however, it was the lowest as compared to the other imported breeds at the station. The body weights of the kids of imported purebred exotic goats (Anglo Nubian-AA, British Alpine-BB and Saanen-SS) were

greater than that of the Katjang-KK kids (Table 4.36). However, the imported breed groups did not achieve the body weights often reported overseas (Mc Gregor, 1980; Chawla et al., 1984; Mohamed, 1984) which may be due to the existence of nutritional and climatological stress. Large variation in dry matter intake has also been reported earlier (Devendra and Nozawa, 1975) in above breed groups which could also be a contributary factor for the lower body weights. It was found that Saanen-SS progeny group recorded the greatest birth, weaning and 12 month body weight followed by British Alpine-BB and then by Anglo Nubian-AA progeny groups. Comparatively, Bhatnagar et al., (1971) indicated that the French Alpine averaged 3.0 kg that of Beetal was 2.8 kg and that of French x Beetal averaged 3.5 kg.

The variability in body weight of Anglo Nubian under different environmental conditions is evident, for example, the 12 month body weight in Sao Paulo (Prucoli et al., 1981) was 18.61 kg whereas in India (chawla et al., 1984) it achieved 33.90 kg as compared to 24.02 kg in Malaysia (present study).

As expected the body weight of the half breds was greater than that of purebred Katjang but not as high as the purebred exotic breeds. Although Devendra (1966) had given higher birth weight for Anglo Nubian grades, there was no significant difference between Saanen x Katjang (SK) and Anglo Nubian x Katjang (AK) progeny groups for birth, weaning as well as 12 month body weight contrary to findings of Mohd.

Table 4.36: Comparative mean body weights of indigenous Katjang and imported exotic breeds of goat at Serdang.

Breed group	Obs	Birth weight (kg)	3 mth weight (kg)	6 mth weight (kg)	9 mth weight (kg)	12 mth weight (kg)
KK	136	1.57±0.05	5.80±0.14	8.30±0.13	9.74±0.16	11.92±0.20
JJ	164	2.48±0.52	8.42±0.21	10.98±0.21	13.83±0.28	16.14±0.28
SS	46	2.94±0.74	10.51±0.61	19.03±1.14	22.32±1.29	25.55±0.96
BB	19	2.92±0.04	9.70±0.06	15.87±1.92	21.89±1.96	24.22±1.90
AA	34	2.60±0.47	10.08±0.66	16.66±0.75	22.88±0.51	24.02±0.65

Breed groups: KK = Katjang purebred
JJ = Jamnapari purebred
SS = Saanen purebred
BB = British Alpine purebred
AA = Anglo Nubian purebred

Khusahry et al., (1980). The advantage of AK and SK over KK ranged from 16.38 to 36.31% in the progeny sired by Saanen and from 22.51 to 31.21% in the progeny sired by Anglo Nubian.

The results also showed that the AK crossbred bucks had the greatest body weight at weaning (11.43 kg) and at one year old (20.43 kg) when compared to KK and SK bucks (weaning weight: 7.42 and 8.28 kg; one year old weight: 13.83 and 17.74 kg, respectively). At one year old the KK bucks attained only 67.49% of the weight of AK. It was also observed that at this age the animals were still growing though at a slower rate contrary to some belief that the local goats mature at one year old. It was later observed that the superiority of the crossbreds was maintained and illustrated even at two years old.

When comparing progeny groups based on sire breeds (Table 4.37), the backcrosses with Saanen inheritance (SK)K though had lower birth weight was found to be heavier at 12 month of age as compared to backcrosses of Anglo Nubian inheritance (AK)K. There was significant difference ($P<0.05$) between the effect of the exotic breed of sire and local katjang sire but there was no difference between the exotic and crossbred sire effects on birth, weaning as well as 12 month body weight. The advantage of Saanen had also been demonstrated by Mc Gregor (1980) where the backcross to the sire breed Saanen X Kili and Saanen X (Saanen X Anatolian black) had recorded better average daily gain when compared to the backcrosses of dam group as in the present study.

Table 4.37: Least square means (±S.E) for birth, Weaning and year old body weights for breed of sire effect in goats at Serdang.

Breed of sire	Birth wt (kg)	Weaning wt (kg)	Year old wt (kg)
A	2.06±0.05[a]	8.31±0.27[a]	16.99±0.70[a]
AK	2.10±0.10[a]	7.85±0.44[a]	17.06±1.30[a]
K	1.58±0.05[b]	6.54±0.26[b]	13.99±0.71[b]
SK	1.91±0.10[a]	7.36±0.47[ab]	18.18±1.44[a]
S	2.14±0.05[a]	8.57±0.28[ac]	16.13±0.78[a]

Values with same superscripts in column are statistically not different (P>0.05)

Breeds : AA = Anglo Nubian purebred
KK = Katjang purebred
SS = Saanen purebred
AK = Anglo Nubian x Katjang crossbred
SK = Saanen x Katjang crossbred

The analysis of variance performed on birth weight, 3, 6, 9, and 12 month body weights demonstrated a highly significant ($P<0.001$) effect of year of birth, season, sex of kid, type of kidding, breed of sire and breed of dam on birth weight. The three month body weight was significantly affected by year of birth and season but not any of the other effects. At 12 month body weight, the year of birth, season, type of kidding, sex of kid and breed of dam had a very significant influence on body weight. Siddique (1981), Sharma et al., (1981) and Singh (1973) had also recorded similar findings. The breed of sire had no significant effect on 3, 6, 9, or 12 month.

4.2.7.2 Body measurements

Variation in body size is one of the criteria used in classifying breeds of goats (Devendra and Burns, 1983). Besides the body weight, morphometric measurements or body measurements are also of value in identifying the quantitative characteristics of meat as well as helpful in developing selective criteria (Bose and Basu, 1984; Sharma et al., 1984; Islam et al., 1991; Mohammed and Amin, 1996). Body measurements have been used to predict body weight in a number of goat breeds (Valdez et al., 1982; Bhattacharya et al., 1984; Mukherjee et al., 1986; Singh et al., 1987; Pittal, 1988; Tizikara and Chiboka, 1988; Mohammed and Amin, 1996).

In the present study there was no difference between birth weight of singles and twins in agreement with

Mohammed and Amin (1996). However, The twelve month body weights recorded in this study were similar to those recorded for the Kottukachiya (Buvanendran et al., 1974), Black Bengal (Singh et al., 1979) and Grey Bengal goats (Mukherjee, 1978). Sexual dimorphism was more evident in the Katjang than in Katjang crossbred goats. Body weight was highly significant between breed groups at all ages but the difference between sexes was significant ($P<0.05$) at 12 months and not at 6 and 9 months of age. Abdul Wahid and Mukherjee (1981) have earlier reported the males to be heavier than the females at various ages.

The advantage of male over female though statistically not significant was also evident in most body measurements. Similar observations were also made by Nishida and Hayashi (1972). However, there was significant difference ($P<0.05$) between the body measurements of purebred Katjang and Katjang crossbreds. The increment between the 6 month body measurements and the 12 month body measurements was also highly significant. The difference between the two breed groups suggested an increment of as much as 12%.

The phenotypic correlation between weight and either height, chest girth, body length, shank length, rump and loin was statistically not significant in male and female goats. In the Katjang crossbred goats the correlation coefficient of body weight was greatest with body length ($P<0.01;r=0.93$) and chest girth ($P<0.01;r=0.91$) which was assumed natural because the major body weight is due to these

two portions of the body. Positive and significant correlation of body weight with body measurements were also reported by Tandon (1966) in the Beetal, Singh et al., (1979) in Black Bengal and Mukherjee (1978) in Brown Bengal and Grey Bengal goats of India.

Using cannon length as the independent variable, body weight of Katjang goats at 12 months of age could be estimated using the equation $Y=7.80X_4-52.77$ where Y is estimated weight and X_4 is the cannon length. In the Katjang crossbred goats the 12 month body weight could be estimated using the equation $Y=1.72X_2-62.97$ where Y is as above and X_2 is chest girth. Chest girth was the best single determinant for estimating the weight of the goat in agreement with Valdez et al., (1982). The multiple regression analysis showed that the coefficient of determination (R^2) values tend to increase as the number of measurements taken is increased. The R^2 values for 12 month weight in Katjang and Katjang crossbreds increased from 0.37 to 0.70 and 0.82 to 0.90 respectively.

.2.7.3 Average Daily Gain (ADG)

The preweaning (0-112 days) and postweaning (113-64 days) ADG (Average Daily Gain) for purebred Katjang (KK) as 53.86 and 26.50 gm/day (Table 4.38). In almost all the rogeny groups the postweaning ADG was about half that of reweaning. The preweaning ADG was greatest in the purebred xotic goats followed by the halfbreds and then the ackcrosses. However, There was no significant difference in

Table 4.39: Average daily gain (gm/day) at preweaning and postweaning for different breedgroups of goat as illustrated in the trial at Serdang.

Breedgroup	Average daily gain (gm)	
	Preweaning (0-112 days)	Postweaning (113-363 days)
KK	53.86 ± 0.003 ^{ad}	26.50 ± 0.003 ^{b}
SK	70.90 ± 0.005 ^{abc}	33.13 ± 0.004 ^{a}
AK	68.60 ± 0.005 ^{abc}	37.02 ± 0.003 ^{a}
(SK) X K	60.39 ± 0.004 ^{ac}	38.98 ± 0.005 ^{a}
(AK) X K	63.59 ± 0.003 ^{ac}	36.68 ± 0.004 ^{a}

Values with same superscripts in column are statistically not different ($P<0.05$)

Breed: KK = Katjang purebred
AK = Anglo Nubian X Katjang crossbred
SK = Saanen X Katjang crossbred
(AK)K = (Anglo Nubian x Katjang) x Katjang crossbred
(SK)K = (Saanen x Katjang) x Katjang crossbred

postweaning ADG of the halfbreds and backcrosses. It was also observed that there was no significant difference in the preweaning ADG of the exotic purebreds (AA, BB and SS). These results are comparable to that reported by Paramsothy (1957). The variation in ADG as reported indicate the potential of the different progeny groups and suggest that with better nutrition and management greater growth rate can be achieved.

4.3 Milk production in goats

4.3.1 Milk production in Serdang

4.3.1.1 Lactation Yield

The present study at Serdang (Table 4.39) showed that the AK breed group produced 0.40 kg of milk per day with range of 0.05-0.620 kg/day. The JK breed group produced on the average 0.335 kg/day with a range of 0.07-0.670 kg/day. The advantage of AK over JK was 19.40%. An earlier report (Abdul Rahim and Abdul Wahid, 1980) also indicated that the Katjang goats produced 0.4 kg of milk per day and 120 kg/year compared to undefined crossbreds which produced 0.75 kg/day and 225 kg/year (Devendra, 1975).

It was observed that these values were comparable to the yields of the local crossbred goats of the Philippines (Castillo, 1983) and that of the Kharasani goat of Pakistan (Khan et al., 1992). These are the small-sized breed groups and thereby have similar productivity of milk. The Pakistan breed produced 0.391 kg/day. Besides being small in size the AK and JK breed groups were the unselected samples and therefore a comparison of milk production between the AK and JK breed groups as compared to the high producing temperate breeds is not justified.

In spite of the fact that JK produced more milk per lactation (78.54 kg) as compared to AK (59.46 kg), due to greater persistency (Figure 4.16) the annual milk production of the above two breed groups was calculated as 147.64 kg and 127.82 kg/annum respectively which was comparable with some

Table 4.39: Milk productivity of AK and JK breed groups of goat at Serdang.

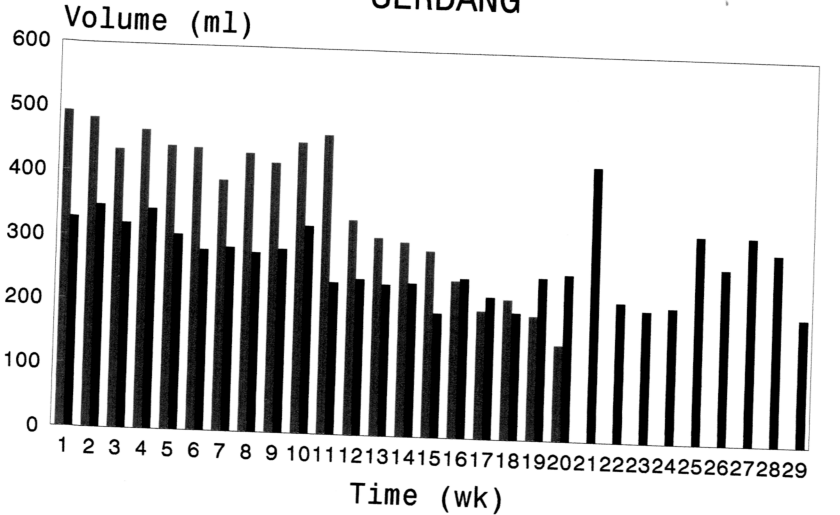
Variable	AK Mean (±S.E.)	JK Mean (±S.E.)
Volume (ml)	404.5±9.4$_a$	350.2±6.3$_b$
Butterfat (%)	3.628±0.088$_b$	3.914±0.656$_a$
SG (No.)	1.031±0.0001$_a$	1.031±0.0009$_a$
SNF (%)	8.601±0.026$_a$	8.824±0.025$_b$
Lactation yield (kg)	59.47$_b$	73.54$_a$
Lactation length (days)	147.0$_b$	210.0$_a$
Annual yield (kg)	147.64$_a$	127.82$_b$
No. of animals	42	72

a, b - Values with different subscripts in row are statistically different ($P<0.05$).

Breed group: AK = Anglo Nubian x Katjang

JK = Jamnapari x Katjang

FIG 4.16: MILK PRODUCTION OF GOATS AT SERDANG



of the tropical breeds (Castillo, 1983; Khan et al., 1992).

The advantage of F1, F2 and BC2 of German Fawn x Katjang at Universiti Malaya have out-yielded these two breed groups by recording lactation length yield of 289, 216 and 251 kg in an annual lactation (Stemmer, 1993). This was evidently due to the fact that the goats in Universiti Malaya were of a selected group whereas those used in the study in Serdang and Kluang for that matter were never milked nor were they selected for milk production. As a result the lactation yield varied between the different breed groups.

Mukundan and co-workers (1983) found that the coefficient of variation for lactation yield was large which indicated a large inter- and intra-breed variability in lactation yield. This suggested that there is ample scope for improving milk production through selection. Earlier, Bhat (1977) had also reported the CV (coefficient of variation) to range from 45-70% in Indian goats.

The variation in lactation yield has also been reported in Indian breeds of goat (Acharya et al., 1982): Beetal = 124 kg (Bhatnagar et al., 1971), Beetal = 87.18 kg Yadav et al., 1983), Barbari = 137 kg (Prakash et al., 971), Barbari = 62.78 kg, Jamnapari = 62.67 kg, Black Bengal 32.41 (Yadav et al., 1983), and Malabari = 49.9 kg Mukundan et al., 1983). The temperate breeds of the Swiss egion can produce 800 kg in 300 days and high performing oats can yield upto 2000 kg/annum (Sands and McDowell, 978). The Anglo Nubian which has been developed in England

can produce 750-990 kg in 276 days in temperate regions (Sands and Mc Dowell, 1978) where the environmental temperature and humidity are condusive. Metz et al., (1985) suggested significant effect of breeding group, litter size and lactation number on milk yield.

The productivity of milk of the different breeds of goat of the world is so variable that the indigenous goats in the tropics produce 0.5-2.5 kg/day, exotics in the tropics produce 0.6-3.4 kg/day and the exotics in the temperate environment produce 2.7-4.1 kg/day (Devendra 1975; Ruvuna, et al., 1983; Galal, 1987; Steinback, 1987). Gerona and Posas (1983), in the Philippines, reported that the temperate breeds Saanen, Anglo Nubian, Toggenburg and Alpine produced 2.65, 2.33, 2.07 and 1.42 kg/day respectively in the tropics. However, Castillo (1983) reported that the Saanen gave average daily production of 1.8 kg whereas the Anglo Nubian gave 1 kg/day. The Barbari (Dutt, 1968) produced 0.9 kg/day with highest yield of 1.78 kg/day and the lactation length was 192 days which was significantly greater than that in the present study.

Crossbred genotypes (Saanen, Alpine and Toggenburg, etc) with the local breeds in some countries also produced more milk at peak lactation as compared to local genotypes (Ruvuna et al., 1980). Mukundan et al., (1983) obtained an increase of 139% in yield by crossbreeding and in Ya'an city of China the milk yield have increased from 200 to 400 g/goat by crossing with Saanen (Leonard, 1992). In Western

China where Xiang Saanen is used to upgrade the local goats, milk production has been reported to be 800 kg/lactation (Luo, 1992). Katjang x German Improved Fawn crosses in Malaysia produced almost 400% more milk than their contemporaries at the University of Malaysia farm (Mukherjee et al., 1992)

F_1 can yield 80-100% more milk than local goats. In Malaysia improved yields of 296 kg over a 235 day lactation period have been obtained from the cross between Anglo Nubian and Katjang goats at the Institut Haiwan (Annual Report, 1986). However, such a phenomenon was not recorded in the present study where the local Katjang and the crossbreds were found to have similar yields. Mishra et al., (1982) also did not find any increase in the lactation yield or lactation length of the crossbreds. The yield of the Katjang as compared to the Jamnapari x Katjang was 120 kg/year and 127.82 kg/year respectively. The Jamnapari x Katjang only produced 6.5% improvement as compared to the Anglo Nubian x Katjang crossbreds which produced 23.03% improvement in the annual yield by crossing the local Katjang with imported and adapted Anglo Nubian and Jamnapari breeds.

It appears that temperate goats when transferred to the tropics produce less milk possibly due to inadequate nutrition, heat stress, poor management and absence of proper selection procedures within the breed. In fact it was earlier reported that the Saanen breed was not able to acclimatize to Ghana and Malaya but were successfully introduced into the

Carribean (Devendra and Nozawa, 1975). However, with improved husbandry most of the temperate breeds were able to adapt to tropical environment and produce milk though not as much as they would in the temperate countries.

4.3.1.2 Lactation length

The average lactation length for the goat varies from 100 to 210 days. In the present study the lactation length of AK was 147 days and that of JK was 210 days. There was significant difference ($P<0.05$) between the two breed groups. The range in the different breeds of goat is Sirohi=187.7 days (Barhat and Choudary, 1978), Barbari=192 days (Bhatnagar et al., 1971), Jamnapari=106.3 days (Khan and Sahni, 1983), Chegu=187.1 days (Mazumder and Mazumder, 1983), Malabari=139.5 and Saanen=215.0 days (Mukundan et al., 1983).

Duration of lactation is dependent on genetic factors (Mukundan et al., 1983), feed supply (Morand-Fehr and Sauvant, 1978) and the adequacy of milking techniques.

In the present study milk yield seemed to decrease with advancing lactation (Figure 4.17), whereas butterfat increased in the two breeds (Figure 4.18). In this study the milk production curve (Figure 4.19) showed that the AK breed group though produced higher milk yield dried up early and by 10th week was almost dry. The lactation curve suggests the trend that the AK breed group is a short term producer of milk whereas the JK breed group is a better choice for long term milk production. There was significant difference ($P<0.05$) between the two breed groups.

FIG 4.17: MILK PRODUCTION TREND IN AK AND JK BREED GROUPS OF GOAT AT SERDANG

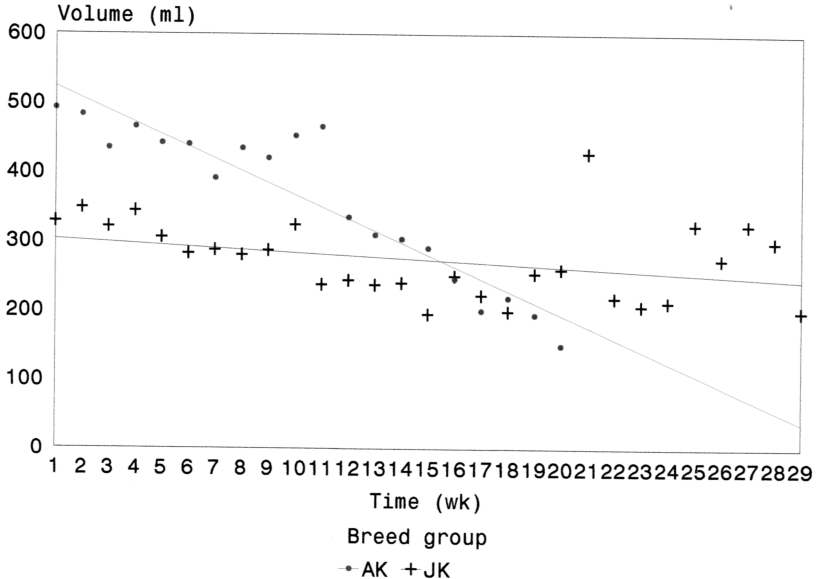


FIG 4.18: BUTTER FAT IN MILK OF GOATS AT SERDANG

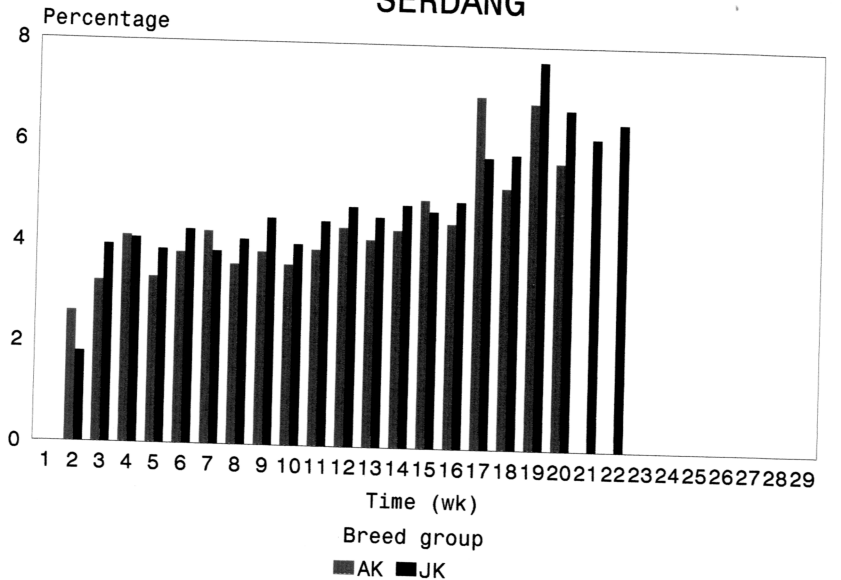
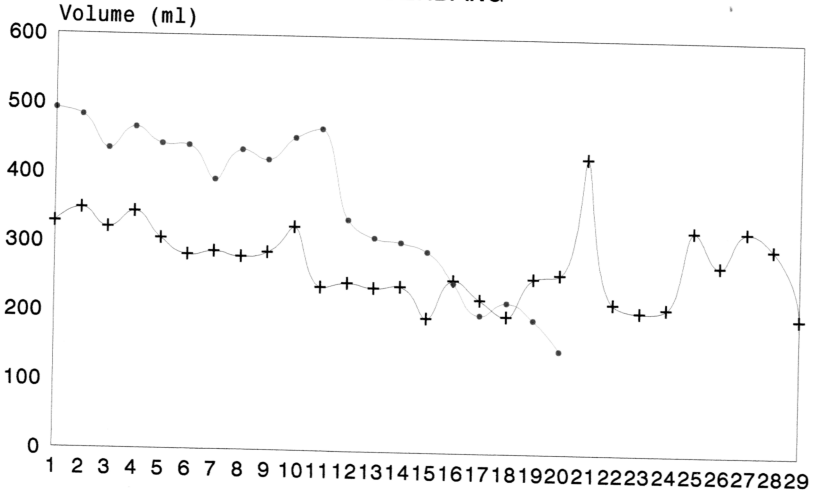


FIG 4.19: MILK PRODUCTION CURVES OF GOATS AT SERDANG



The persistency demonstrated by JK resulted in higher lactation yield and greater lactation length which extended to the 29th week. Persistency is measured by the ability of a milking animal to sustain certain performance over course of lactation. This characteristic is very desirable because dairy farmers would be able to produce greater quantity of milk over a longer period resulting in greater profits.

In the selection of good milking animals in an early selection of progeny, it is useful to estimate total milk production of a particular doe prior to the end of lactation. Although milk yield in the fourth month of lactation alone can give fairly accurate/good estimate of overall lactation yield, it is advisable to test the milk of the first month too, as suggested by Stemmer (1993). She found the correlation between the cumulative monthly and total lactation yield were as high as 0.84 to 1.00.

Stemmer (1993) found significant effect of genotype for total lactation and for early lactation but not for late lactation. The effect of parity was not significant whereas effect of litter size and month of parturition were significant, but only in 1st and 8th month. Yield of does with multiple litters was higher by 14% compared to does with singles.

4.3.1.3 Butterfat content

The butterfat was higher in the milk of the JK breed group (Fig. 4.18) as compared to the AK breed group

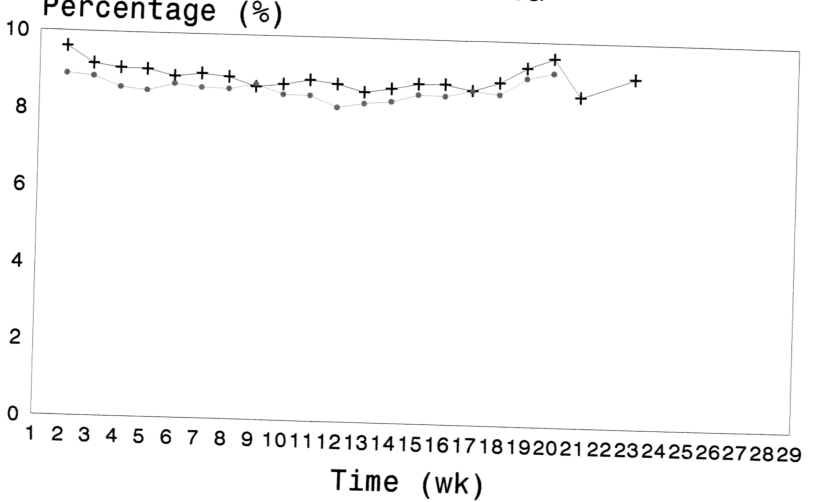
(3.914% versus 3.628%). Butterfat in the milk is very variable as it is influenced by the quality of feed as well as the environment. As compared to the JK breed group, the AK would be able to produce milk that is more easily digested by young children as the fat percentage is low. However, the milk has to be diluted with luke warm water to reduce the fat percentage to a safe level before feeding.

The butterfat increased towards the later part of lactation. An inverse relationship was recorded between the yield and butterfat contents. There was significant ($P<0.05$) difference between the AK and JK breed group for butterfat (Figure 4.18) and SNF (Figure 4.20).

As mentioned above the butterfat in JK breed group was greater compared to AK though the Anglo Nubian purebred has been reported to be greater in butterfat and SNF content. Quite often goats that produce more milk have lower butterfat content such as the Saanen and the higher total nitrogen in the Jamnapari goat milk possibly influenced the higher SNF in the milk of the JK crossbred goats.

The butterfat content of goat's milk is very variable e.g. 2.95-3.75% in Saanen, 5.00-9.00% in West African Dwarf and 4.10-5.50% in Red Sokoto (Mba et al., 1975), and Mukherjee (1991) quoted that fat percentage in goat milk can be as high as 8%. Genetic differences influence composition of goat milk (Devendra, 1972; Stemmer, 1993) and among the temperate breeds the Nubian produce milk which is richer in solids, fat and SNF (Devendra 1972;

FIG 4.20: SOLID-NON-FAT IN MILK OF GOATS AT SERDANG



Chandan et al., 1992). However, in the present study the JK breed group produced milk which is higher in butterfat and solid-non-fat. Among the Indian breeds, Agnihotri and Prasad (1992) reported that the Black Bengal had the highest total solids, fat and solids-not-fat and the Beetal milk had the lowest. The Saanen produces a large volume of milk with low fat content (Chandan et al., 1992).

4.3.1.4 Solids-non-fat

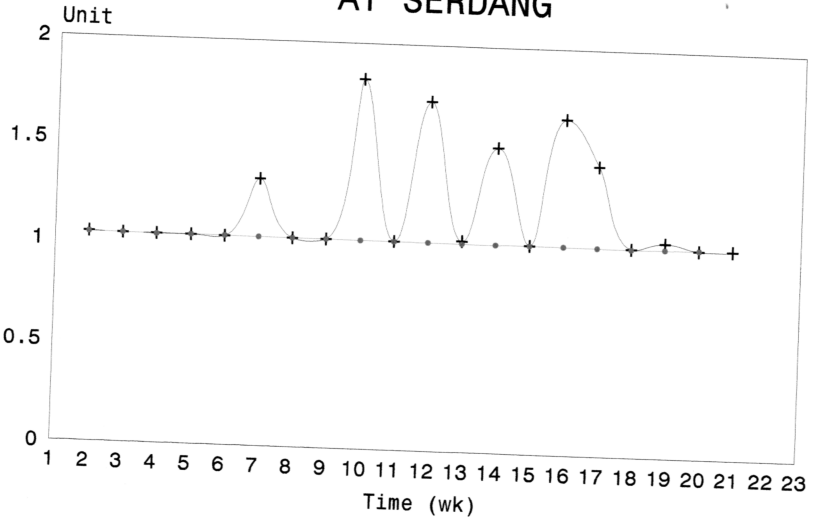
The SNF values of AK (8.601%) and JK (8.824%) were similar to that of Saanen (8.24-9.38%), but lower than that of West African Dwarf (9.49-10.95%) and Red Sokoto (9.96-10.69%). The higher the solids-non-fat level in milk, the better is its keeping quality. It has been pointed out by Mba et al., (1975) that local indigenous breeds produce more SNF than do exotic breeds. Protein and lactose can also influence the SNF content.

There was significant difference ($P<0.05$) in the energy values of goats' milk. The gross energy content of milk of AK and JK breed groups, calculated using the formula: $Y = 39.618 \pm 9.54X$ where Y=kcal/100ml of milk and X=the fat percentage in the samples studied, was 74.23 kcal and 76.96 kcal/100 ml of milk respectively.

.3.1.5 Specific gravity

There was no significant difference ($P>0.05$) between the SG of AK and JK (Figure 4.21). However, there was

FIG 4.21: SPECIFIC GRAVITY OF GOAT MILK AT SERDANG



a distinct pattern in AK from the 10th week to 16th week where the SG of AK was higher than that of JK. This trend was only observed in Serdang but not in Kluang.

4.3.2 Milk production of goats in Kluang.

4.3.2.1 Lactation Yield

With the introduction of Saanen into the existing 2-way crosses, it was found that the progeny of the 3-way crosses (S(AK) and S(JK)) produced greater quantity of milk compared to the dam breeds (AK and JK). The average daily milk yield was more than doubled in S(AK) (AK=620 ml; S(AK)=1300 ml) and almost doubled in S(JK) breed in respect to JK (JK=620 ml; S(JK)=1200 ml) (Table 4.40). The S(AK) breed group contributed 109.68% improvement over AK whereas S(JK) demonstrated 93.55% improvement over JK. It appears that S(AK) is a better combination for milk production and the Saanen has a better combining ability with Anglo Nubian x Katjang crossbred compared to Jamnapari x Katjang crossbred. However, keeping in view that it is difficult to identify and differentiate between the two parent groups as farmers in the small holder farms of Malaysia do not keep records, it is possible to achieve between 93.55 to 110% improvement just by distributing Saanen bucks to the farmers.

The effect of genetic and non-genetic factors on milk production has been studied by Singh and his colleagues as early as 1970. They suggested that year, season of kidding, and lactation length had highly significant effect on milk yield and explained that 63% of total variability in milk yield is in the first lactation. Lactation length itself accounted for 58% of total variability.

Table 4.40: Effect of introduction of Saanen on quantity and quality of milk in the goats.

Variable		BREED GROUP AK	JK	S(AK)	S(JK)
Volume (ml)	Max.	620_b	620_b	1300_a	1200_a
	Min.	50_a	70_a	50_a	50_a
Fat (%)		$3.11 \pm 0.15_b$	$2.87 \pm 0.16_b$	$3.70 \pm 0.26_a$	$3.50 \pm 0.15_a$
SG (No.)		$0.99 \pm 0.04_b$	$0.97 \pm 0.04_b$	$1.30 \pm 0.00_a$	$0.96 \pm 0.03_b$
Solid-not-fat (%)		$8.46 \pm 0.10_a$	$8.59 \pm 0.10_a$	$8.19 \pm 0.09_b$	$8.22 \pm 0.06_b$
Lactation yield (kg)		42.21_c	36.64_c	85.05_a	74.38_b
Lactation length (days)		126.0_a	112.0_b	126.0_a	119.0_b
Annual yield (kg)		122.28_c	124.93_c	246.38_a	228.13_b
No. of does		16	19	20	24

a, b Values with same subscripts in row are statistically not significant (P>0.05).

Breed group: AK = Anglo Nubian x Katjang
JK = Jamnapari x Katjang
S(AK) = Saanen (Anglo Nubian x Katjang)
S(JK) = Saanen (Jamnapari x Katjang)

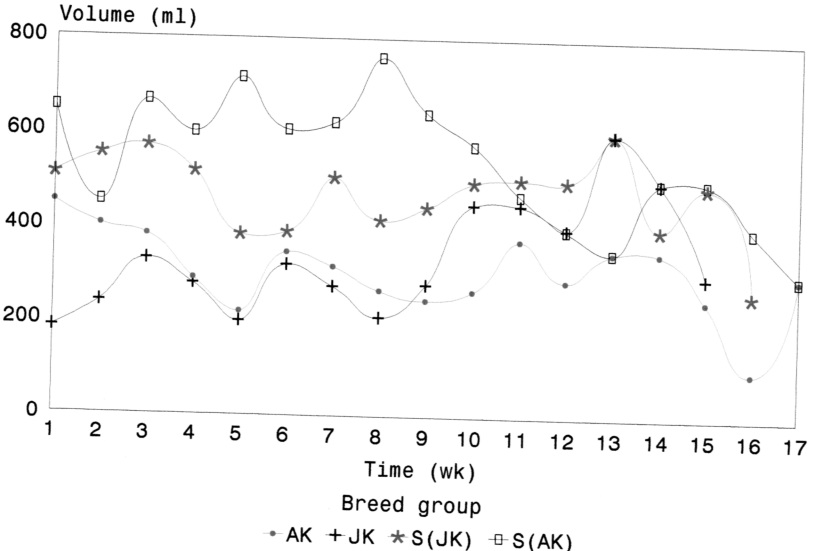
Gall (1969) further showed that about 60% of variation in yield was attributable to body weight, rumen volume, skeletal size, muscle volume and body fat. Milk production has been shown to be correlated with body weight (Orliyanskii and Zaporozhtsev, 1974) in the Don goats. It was also reported that 80% of total variation in milk yield was related to variation in body measurements (Gall, 1973).

4.3.2.2 Lactation length

The lactation lengths of all the breed groups were slightly shorter (Figure 4.22), however, S(AK) produced 85.05 kg of milk per lactation compared to S(JK) which produced 74.38 kg of milk per lactation. There was significant difference ($P<0.05$) between the two breed groups (S(AK) and S(JK)). Based on annual yield the S(AK) produced more milk than S(JK) by 13.9% and more than AK by 101.49%. The extra amount of milk produced (124.1 kg) if sold at existing market price of MR 10.00/kg would significantly add to the annual income of the farmers (MR 1241.00).

The trend in milk production was similar in AK, and (JK) breed groups. In the S(AK) the milk increased to the ighth week and then declined. Similar trend was observed by ill and Dev (1972) in the French Alpine and Anglo Nubian here the peak lactation was in the second and third week and hen declined to tenth week. In the 2 year milking goats alins (1971) observed that there was a second peak at the 8th week which declined at the 68th week. In the present tudy it was noticed that in JK the milk increased with

FIG 4.22: MILK PRODUCTION CURVES OF FOUR BREED GROUPS OF GOAT AT KLUANG



advancing lactation which is an interesting phenomenon that needs further investigation. Milk yield is reported to increase with age until 3rd to 5th lactation and then decreases (Iloeje and Vleck, 1978). Butterfat was found to be lowest in first lactation (3.5%) and then greatest (3.7%) in 6th lactation (Iloeje and Vleck, 1978).

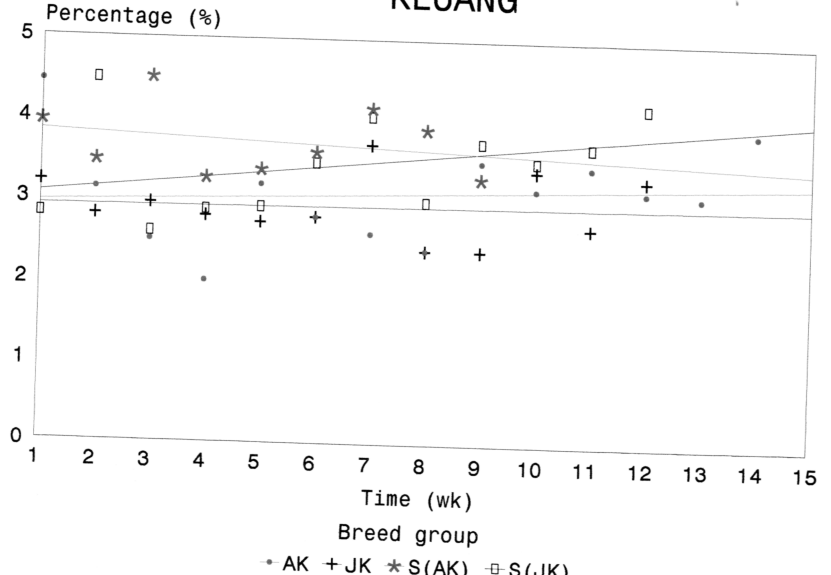
An average dairy goat will produce 1/2 gallon of milk each day during lactation period of 7-10 months (Malins, 1971). Just after kidding most goats can produce at least one gallon a day. Some Saanen dairy goats in Australia have recorded 3090.9 kg of milk a year with an average of 1.9 gallons per day (Malins, 1971).

4.3.2.3 Butterfat content

The S(AK) produced 3.70% butterfat and the S(JK) produced 3.50% butterfat. The Anglo Nubian component could have contributed the extra fat as pointed out by Prakash and Jenness (1968) and Devendra (1972) that the Nubian breed produces milk which is rich in fat and SNF.

There was significant increase in butterfat of S(JK) compared to S(AK) (Figure 4.23). The butterfat of S(JK) over the dam breed group JK increased by 21.95% whereas that of S(AK) over AK breed group increased by 18.97%. However, these values were lower than those reported by Castillo 1983) in triple cross does which also contained 50% Saanen enome. He reported the triple cross of Saanen with Jamnapari nd Batangas to produce 74 litres of milk in a period of 76.3 days with butterfat of 4.96% as compared to the native

FIG 4.23: BUTTER FAT IN MILK OF GOATS AT KLUANG



breed group which produced 39.8 litres of 6.14% butterfat in a milking period of 149.7 days. It was also noticed that the butterfat of AK and JK was lower than that of the same breed groups in Serdang. A number of reasons could be given that would have produced the effect, such as nutrition or variation in the feed provided, age of the animals, size of the animals (Clamohoy et al., 1959), lactatinal status of the animals, etc.

Breed differences in fat content of goats milk are well established. Among the temperate breeds Anglo Nubian produce milk which has higher fat content (Prakash and Jenness, 1968). Butterfat was found to be lowest in first lactation (3.5%) and then greatest (3.7%) in 6th lactation (Iloeje and Vleck, 1978). The fat and SNF have been shown to decline to a minimum at about 4th month of lactation (Knowles and Watkin 1938; Gamble et al., 1939; and Ronnigen, 1965 as quoted by Devendra, 1972).

There was significant increase in butterfat of S(JK) compared to S(AK). The butterfat of S(JK) increased by 0.63% whereas that of S(AK) increased by 0.59%. However, these values were lower than those reported by Castillo 1983) in triple cross does also containing 50% Saanen enome. He reported the triple cross of Saanen with Jamnapari nd Batangas to produce 74 litres of milk in a period of 76.3 days with butterfat of 4.96% as compared to the native reed group which produced 39.8 litres of 6.14% butterfat in milking period of 149.7 days. It was also noticed that the

butterfat of AK and JK was lower than that of the same breed groups in Serdang. A number of reasons could be given that would have produced the effect, such as nutrition or variation in the feed provided, age of the animals, size of the animals (Clamohoy et al., 1959), lactational status of the animals, etc..

4.3.2.4 Specific Gravity (SG)

The SG was 1.30 compared to 0.96 in S(AK) and S(JK) respectively. There was significant difference ($P<0.05$) between the two breed groups. The higher SG (Figure 4.24) which usually is related to low fat is possibly due to the introduction of Saanen which produces more milk with less fat (Chandan et al., 1992). Milk which is adulterated with water will also have a higher SG.

The energy value of the milk in S(AK) and S(JK) was 74.47 kcal and 72.56 kcal/100 ml of milk.

4.3.2.5 Solid-non-fat (SNF)

The SNF of the two-breed groups (AK and JK) was higher than that of the three-breed groups (Figure 4.25) and the difference was statistically different ($P<0.05$). The SNF of S(AK) (8.19%) was lower to that of S(JK) (8.22%), however there was no significant difference between the two breed groups. The lower SNF could be the effect resulting from the influence of protein and lactose.

FIG 4.24: SPECIFIC GRAVITY OF GOAT MILK AT KLUANG

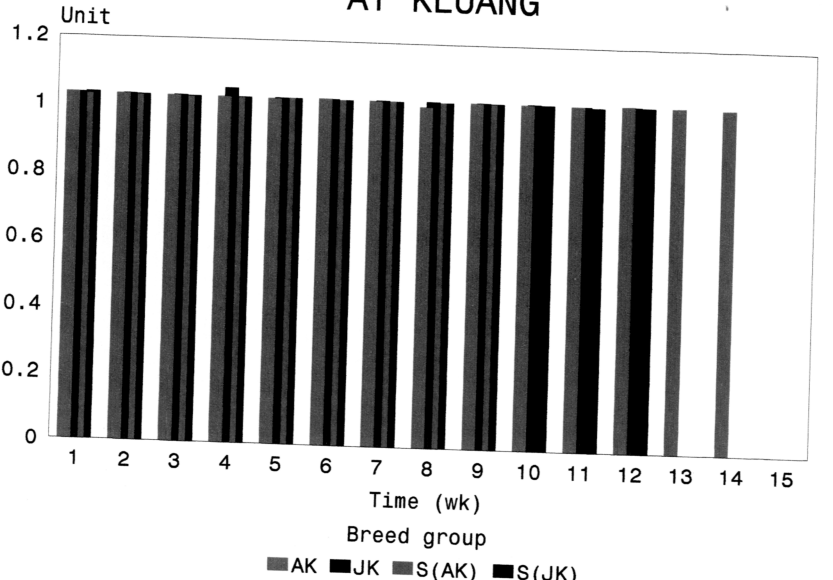


FIG 4.25: SOLID-NON-FAT IN MILK OF GOATS AT KLUANG